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COMPONENT RELIABILITY DATABASE FOR WEAPONS SYSTEMS

by

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March 1994

Principal Advisor: Keebom Kang

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This study concentrates on one weapon system, the 5" 54 MK 45 gun system. We developed a real time data collection program that is currently being used by Comarco Engineering Support Division to collect data from naval gunfire support missions. SPC methods are then used to identify deficiencies with specific blocks of the gun system. By having a reliable simulation of the weapon system, like the one written at NPS for the 5" 54 MK 45, the program manager is better able to evaluate the various alternatives of spending the programs money, e.g., increase the reliability of a component or reduce the repair time. This way he is better able to spend the programs money more effectively in order to improve the readiness of the weapon system and the U. S. Navy.

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COMPONENT RELIABILITY DATABASE FOR WEAPONS SYSTEMS

by

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the requirements for the degree of

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ABSTRACT

By combining accurate real time data collection, statistical process control (SPC) methods, and a reliable simulation program, system engineers and Naval logisticians will be better able to realize real savings in monetary terms, increased Operational Availability and decreased mission time.

This study concentrates on one weapon system, the 5" 54 MK 45 gun system. We developed a real time data collection program that is currently being used by Comarco Engineering Support Division to collect data from naval gunfire support missions. SPC methods are then used to identify deficiencies with specific blocks of the gun system. By having a reliable simulation of the weapon system, like the one written at NPS for the 5" 54 MK 45, the program manager is better able to evaluate the various alternatives of spending the program's money; e.g., increase the reliability of a component or reduce the repair time. In this way he is better able to allocate his budget more effectively in order to improve the readiness of the weapon systems and the U. S. Navy.

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I. INTRODUCTION

During the Reagan Presidency, the United States military went through an enormous build up. Money seemed almost inexhaustible, but with the breakup of the Russian war-fighting machine, and the end of the cold war era, the United States military has been left without a large and dangerous adversary. Consequently, domestic issues, the most important being the national debt, have become priority issues with President Clinton. As the U. S. Navy along with the other armed services are forced to downsize, due to budgetary constraints, each must ensure that its budgetary dollars are being spent wisely, without decreasing the readiness of our nation's armed forces.

Today's war-fighting machines are extremely complex in design, operation and maintenance. Each individual component that goes into a complex weapon system is designed and engineered for a specific reliability. Individual components are combined into blocks, which are major subsections of the weapon systems. These blocks in turn determine the weapon system's overall reliability design goal.

Ultimately, the time it takes to complete a mission, employing that complex weapon system, is derived from the weapon system's reliability, and the corrective maintenance that is employed (Blanchard, 1992, p. 70). Currently, there

does not exist a real time accurate reporting system or database to track individual block reliability and their repair rates. The Naval Warfare Assessment Center has been tasked to maintain and operate a database on all shipboard weapons systems. But, the inputs they currently receive to update the database from the fleet have left doubts to the validity of the database.

We have developed a real time data collection program to accurately collect data from naval gunfire support missions. Coupled with a program, developed at the Naval Postgraduate School, that simulates the 5" 54 MK 45 weapon system, and statistical process control methods to monitor the weapon system, we are better able to draw conclusions about the 5" 54 MK 45 weapon system.

The objectives of this thesis are to show that a tool such as Lotus 123 can be utilized to write a data collection program, and combined with an accurate simulation of the weapon system, enhance Operational Availability, and decrease mission time. Block failures and the time it takes to repair them can be collected during Naval Gunfire Support (NGFS) exercises, and later analyzed. Then, by using a Statistical Process Control (SPC), the database can be analyzed by Navy logisticians and engineers to identify training and mechanical problems, and engineering deficiencies within a block on a

specific ship. Deficiencies then can be concentrated on and overcome.

This study concentrates on one weapon system, the 5" 54 MK 45 Mod 0 gun system, but the methodology can be utilized for any complex weapon system. We will be focusing on the performance and failures of components of the gun system during NGFS missions, and the time it takes to conduct corrective maintenance after a block failure. By providing a tool such as a real time data collection and simulation program for the gun system, the Navy will be better able to realize real savings in Operational Availability whether it is measured in mission performance or in monetary terms. An accurate database for the weapon system can help identify those components that would be the best candidate for some sort of monetary infusion, whether it be in training for faster block repair, re-engineering for easier repair or higher reliability, modularization of a component, or a multitude of other options (Bailey et al., 1992). A Navy logistician or system engineer, utilizing the weapon system simulation program could save the Navy money by accurately forecasting what benefits would be anticipated by an increase in block reliability, or faster repair rates and whether these options are going to be worth the expenditure of money.

Because of the technical complexity of this thesis and the time limitation, we do not intend to get into the logistical

nature of how many spare parts should be stocked and where, or how many technical maintenance men and their experience and rank there should be for each gun mount. We understand these are important issues that can have a significant impact on system repair time, but it is beyond the scope of this thesis.

Recent work by Bailey, Bartroli, Kang, and Callahan, (1992) has led to the idea and continued research for this thesis. Currently, Mr. Callahan of Comarco Engineering Support Division is collecting data from NGFS exercises using a prototype real time data collection program, written in Lotus 123. Results are being use ate the 5" 54 MK 45 gun system simulation. The gun sys imulation program is currently undergoing tests to verify its validity.

The thesis is organized as follows. Chapter II provides a brief overview of the 5" 54 MK 45 gun system, reliability, SPC, and the measurement of mission time. Chapter III provides the reader with the methodology used to develop the Lotus 123 data collection program, the simulation program, and SPC methods used to analyze block and component failures. Chapter IV provides an analysis of data collected during NGFS missions, and how it is used to update and run the simulation of the gun system. Chapter V provides the reader with conclusions and recommendations. The following is a list of the Appendices which are referenced throughout this thesis:

APPENDIX:	DESCRIPTION
A	ABBREVIATIONS
B	RELIABILITY BLOCK NAMES
C	EQUATIONS FOR OPERATIONAL AND INHERENT AVAILABILITY
D	EXAMPLES FROM REMOTE ACCESS PRODUCTS SCREENS
E	SHIPS PROGRAM-GUN SYSTEM DATA COLLECTION SCREENS
F	SPOTTERS PROGRAM DATA COLLECTION SCREENS
G	PROJECTILE AND POWDER DATA FROM 44 SHIPS
H	DATA COLLECTED AND USED IN THE ANALYSIS
I	SIMULATION DATA SHEETS

II. BACKGROUND, LITERATURE REVIEW AND THEORETICAL FRAMEWORK

For years, the United States Naval forces have been built and structured toward their Soviet opponents. But, for over thirty five years of cold war tension, there was never a single exchange of fire. Yet, at the same time, the Navy has found itself engaged in numerous conflicts with lesser powers. Some would say that less threatening but perhaps more likely dangers have been given less attention and planning. (Breemer, 1983, p. 4) Our complex and sophisticated carrier battle groups and amphibious readiness groups are designed and have proven devastating against adversaries large and small. But, with the retirement of the four WWII Iowa class Battleships and their 16" guns, the Navy has left its Naval Gunfire Support (NGFS) mission to the 5" 54 MK 45 gun system.

With the U. S. Navy downsizing, the 5" 54 MK 45 gun system is destined to be the workhorse of the fleet, from air and small craft defense to NGFS missions. The Navy is banking on this multi-mission weapon system to perform for many years to come. The Navy must therefore place an emphasis on the weapons system's reliability and mission performance.

The gun system was approved for service in July, 1972. Currently, there are two different configurations of the weapon system operating in the fleet. The Mod 0 has been installed on the Nuclear Powered Guided Missile Cruiser (CGN-

36 and 38) class ships, and the Landing Helicopter Assault (LHA-1) class ships. The Mod 1 has been installed on the Destroyer (DD-963), Guided Missile Destroyer (DDG-993), and the Guided Missile Cruiser (CG-47) class ships. (Commander, Naval Sea Systems Command, 1985, p. 1-1)

The 5" 54 MK 45 gun system is an automatic, light weight, dual purpose weapon system capable of firing 16 to 20 rounds per minute depending on elevation. Its operational characteristics are as follows:

Train limits	340 deg
Maximum Train Velocity	30 deg/sec
Train Acceleration	60 deg/sec
Elevation Limits	-15 deg to +65 deg
Maximum Elevation Velocity	20 deg/sec
Elevation Acceleration	40 deg/sec

A simplified pictorial of the 5" 54 MK 45 Mod 0 gun system is shown in Figure 2-1. Reliability block names for the gun system are shown in Appendix B. (Commander, Naval Sea Systems Command, 1985, p. 2-1) The gun system is capable of firing a number of different projectiles for different missions, and the Navy is still developing other projectiles from laser guided projectiles like the U. S. Army's Copperhead to a rocket assisted long range projectile, in order to enhance this weapon systems multi-mission role. (Breemer, 1983, pp. 79-83)

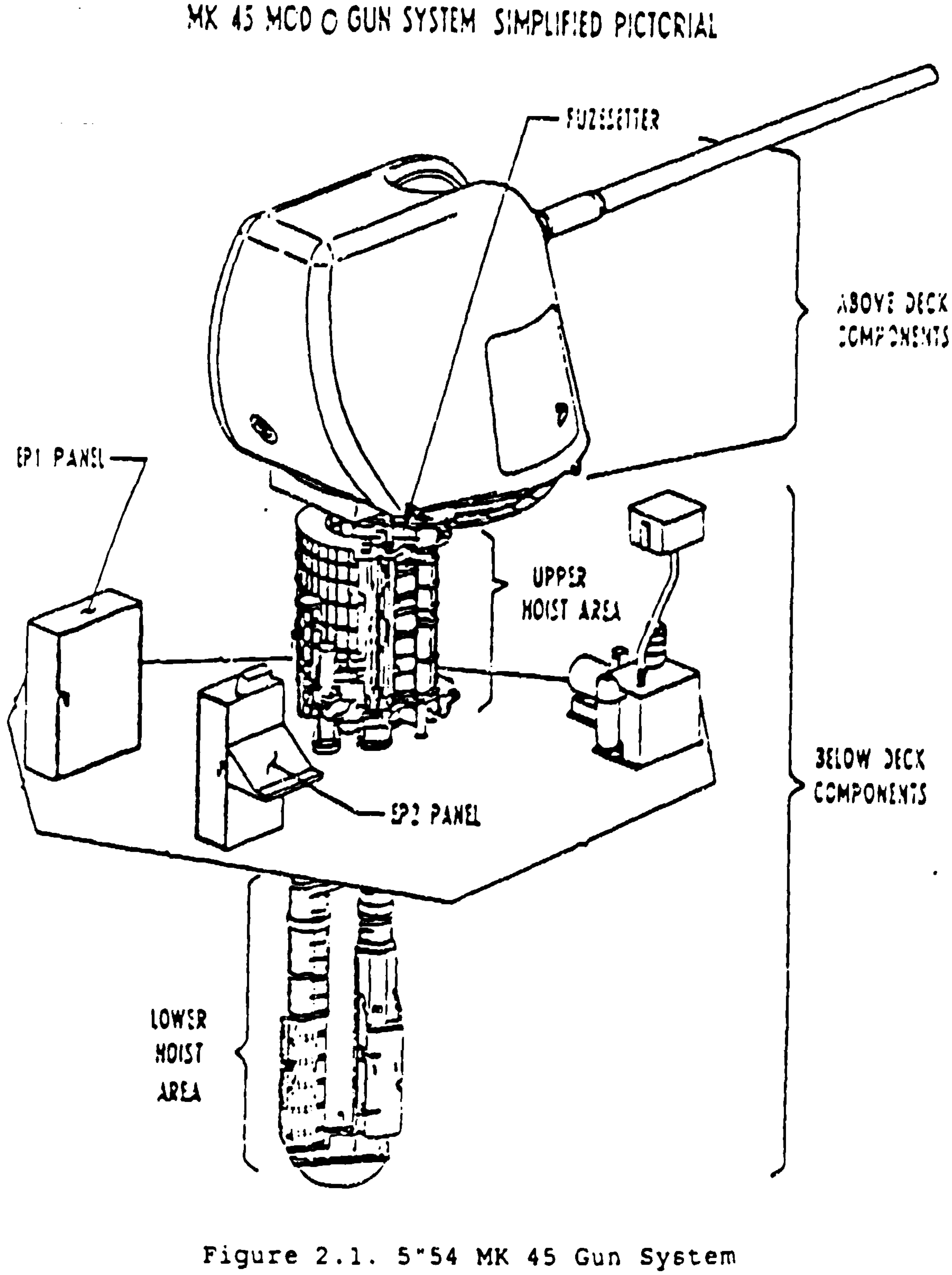

Figure 2.1. 5"54 MK 45 Gun System

(NAVSEA ILSP 021-P/D)

Performance of NGFS missions may be measured in terms of mission time, block and weapon system reliability, Operational Availability and Inherent Availability. Mission time is defined as the time it takes a ship to complete a firing mission and destroy all of her assigned targets. Mission time may include firing time, and down time due to gun system failures. If the mission can not be completed because the gun system has become inoperable and can not be repaired, mission time will end when the ship removes itself from the gun line or conflict. (Callahan, 1993)

Reliability is "the probability that a system or product will perform in a satisfactory manner for a given period of time when used under specified operating conditions" (Blanchard, 1992, p. 14). Reliability measurements are based on the number of failures per total operating time. The Navy requires the use of Mission Profile criteria in order to calculate reliability factors. Mission Profile calculations allow senior military commanders to more accurately predict the amount of total firepower that is required on-scene to complete a specific mission in a specific time frame.

Reliability allocation and design goals are used to build complex weapon systems. For the 5" 54 MK 45 Mod 0 gun system, the reliability design goal was .90. This reliability goal was then allocated among the various 55 blocks that make up the gun system. Components that make up the blocks were then

engineered and combined together to make up that individual block's reliability design goal. This in turn represents the frequency of corrective maintenance that will be required for the block, and the logistical resources that will be required to sustain the gun system. (Commander, Naval Sea Systems Command, 1985, p. 1-3)

Block and system level reliability calculations are based on time elements (calendar time, active time, inactive time, uptime, downtime, energized time, and secured time), event elements (number of failure events, number of failure events with measured downtime, number of logistic delays, number of outside assistance delays), cycle/rounds fired elements (number of cycles, and number of rounds fired), and usage factors (duty factor, demand factor, program manager demand factor, usage factor, and 100 percent use factor). (Commander, NWAC, Readiness, 1993, pp. B3401.010-.020)

Operational Availability is the probability that a weapon system, block or part is in an operable state when needed. Inherent Availability is the probability that the weapon system, block or part is in an operable state, when needed in an ideal support environment (all required parts, manpower, and training are available on board). (Commander, NWAC, Remote, 1993, p. A3401.028)

For system level calculations, the Navy assumes that the system follows a Markov process. A Markov process is "A

description of a system state behavior where the system is in a certain state at a specific time, and the probability law of a future system state of existence depends only upon the current state and not on how the system has arrived in that state" (Commander, NWAC, Readiness, 1993, p. B3401.082). To calculate weapon system and block Operational and Inherent Availabilities for a specific weapon system, the Navy currently uses the equations and definitions included in Appendix C. Currently the block and system level reliability is what allows tacticians and operational commanders the ability to predict how any ship's gun system will perform during specified missions. Predictability is knowledge, and the more knowledge a commander "in the field" has, the better chance he will have in defeating his opponent.

There are many methods that may be used to monitor the weapon system. We have chosen to use control charts and Pareto analysis. These Statistical Process Control (SPC) methods allow us to gain knowledge and monitor a ship's gun system and disseminate it from the highest policy makers, down to the "wrench turners" on the ships.

The major objective of SPC is to detect the occurrence of uncontrollable variation, so that investigation of the process and corrective action may be taken. "The main benefit of SPC is predictability, for process performance will not vary over time so long as process control is maintained." (Schonberger,

1991, p. 645) A process is a unique combination of materials, manpower, operating procedures, weapon system, data collection methods, maintenance, and management. If you change a particular aspect of the process, you will change its outcome. These changes in the process whether they be changes in personnel, sloppy or stringent maintenance policies, or different gun systems on different ships will lead to some common cause for controllable variation.

Controllable variation is characterized by a "*stable and consistent pattern of variation over time.*" Controllable variation is directly linked to changes in the process. Some examples of controllable variation are: different gun crews troubleshoot problems differently due to the past history of the gun, and different skill levels of technicians can lead to longer or shorter repair times.

Uncontrolled variation "is characterized by a pattern of variation that changes over time." These changes can be attributed to assignable or special causes. Not only do these assignable causes have a marked impact upon the variation of the data, but they also undermine predictability. (Wheeler, 1985, pp. 4-6) In addition to the multitude of chance or common causes, occasionally there are assignable or special causes that will have a large impact on the criteria we use to measure NGFS performance (mission time, block and weapon system reliability, Operational and Inherent Availability).

Some examples of uncontrolled variation caused by assignable or special causes are: a poorly trained gun crew whose repair times are far longer than the fleets average, and poorly engineered spare parts leading to an increase in block failures.

Control charts and Pareto analysis may be used to estimate the parameters of a process (repair rates, MTBF's), and through this process, determine and improve process capability. The control chart is an effective way to detect and eventually reduce variability. Control chart theory is based on the Central Limit Theorem in statistics. "When samples are periodically drawn from a process and the average of each group calculated, these averages will form approximately a normal distribution regardless of the distribution of the individual readings of the process or parent population." Processes are viewed as being in control or out of control. An in control process is one that has only controllable variation caused by pure randomness in the sample data. An out of control process is one that has uncontrollable variation caused by assignable or special causes. A process is in control when all the points of the process plot between the upper and lower control limits, and there does not appear to be a systematic pattern or trend. A process is viewed as out of control when a process plots outside of the upper or lower control limits; signifying

excessive variation, or behaves in a systematic or non-random manner leading to a pattern. Processes that appear out of control must be investigated for assignable causes. An example of a control chart complete with upper and lower control and process limits is shown in Figure 2.2. (Bhote, 1988, p. 28)

A type I error is concluding the process is out of control when it really is in control. This can be seen when a process plots outside the upper or lower control limits, but the cause is purely by random chance and not by some assignable cause. A type II error is concluding the process is in control when it is actually out of control. Type II errors can be seen when the process plots between the upper and lower control limits, but can be linked to some specific assignable cause. The chance of type I and II errors appearing in the SPC are decreased by increasing the sample size and frequency of samples.

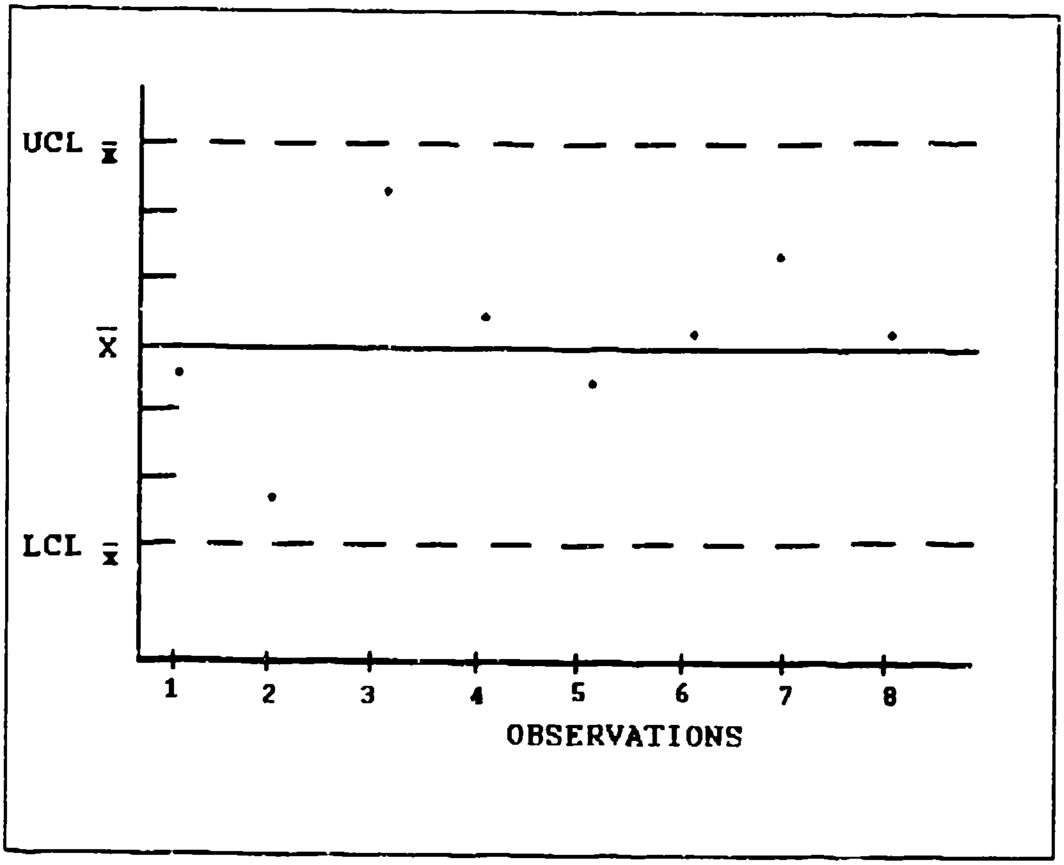

Figure 2.2. Control Chart

The Pareto chart is very useful and easy to use. It allows the engincers, and training commands to concentrate on which blocks are causing the longest delays in repairs by identifying those blocks that are causing the most downtime or longest repair times for the gun system. On the vertical axis of a Pareto chart the percent of occurrences is listed, and on the horizontal axis, the blocks are listed. Figure 2.3 is an example of a Pareto chart. (Schonberger, 1991, p. 665)

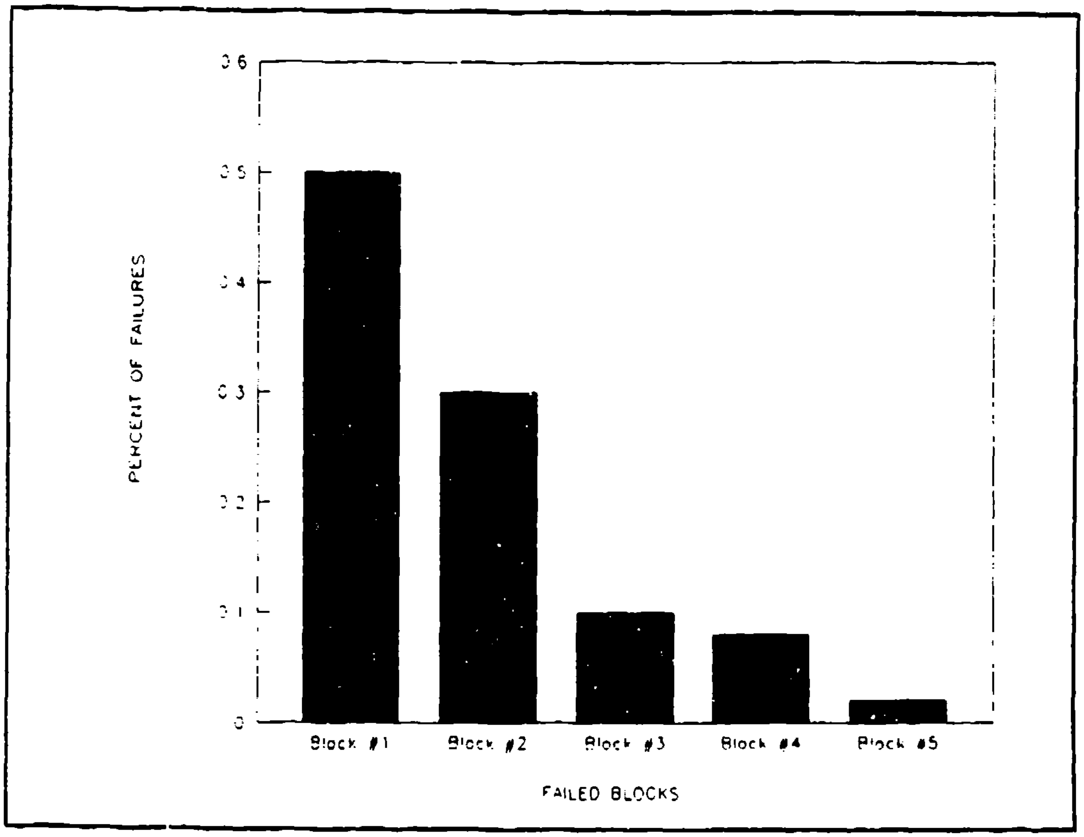

Figure 2.3. Pareto Analysis Chart

Whenever statistical methods such as SPC are employed, it is always possible that the decision reached will be incorrect. This is because partial information, obtained from a sample data collection, is used to draw conclusions about the entire population. For example, data collected may indicate that the particular component is failing excessively and falling above the upper control limit, and thus that particular process is out of control. The process may not be out of control, the excessive failures the ship is seeing in

one particular block may be attributed to randomness. This is the type I error. (Weiss, 1991, p. 248)

The Navy has conducted two reliability, maintainability, and availability (RMA) tests on the 5" 54 MK 45 Mod 0 gun system since its introduction. One, in October 1972 aboard the USS NORTON SOUND (AVM-1), that proved the Mod 0 conceptual design was sound. The other RMA test was conducted between January and December 1984, utilizing fleet data submitted by ships via form 4855 "status logs". The tabulated results are listed below:

Operational Availability	.823
MTBF (hours)	290.0
MTTR (hours)	9.4
MLDT (hours)	26.6
MDTdto (hours)	19.0
MDT (hours)	54.9

MDTdto = MDToa + MDTops + MDTt + MDTd
MDT = MDTs + MDTu
MDTs= Mean-Scheduled-Downtime

See Appendix C for abbreviation definitions. (Commander, Naval Sea Systems Command, 1985, p. 1-5)

Since 1985, the Navy no longer conducts RMA tests. The Naval Warfare Assessment Center (NWAC) in Corona, CA. collects, edits, verifies, and validates fleet inputs for all shipboard systems. These fleet inputs are then loaded into the OP-03 Material Readiness Data Base (MRDB). The NWAC then provides remote access for over 100 users (PMS, ISEAS,

contractors) to the MRDB, and publishes the OP-03 Material Readiness Assessment Report semi-annually. (Commander, NWAC, Remote, p. A3401.006)

Fleet inputs come from the 3M System, casualty reports (CASREPS), received monthly from the Ships Parts Control Center (SPCC), employment tapes, received quarterly from SPCC, steaming hours, and other sources (technical representative ship assists, 3-M, foreign logs, etc). The weapon system Program Manager provides equipment specific assessment criteria such as: editing criteria, reliability block diagrams, time meter assignments for each reliability block, demand factors based on wartime mission profiles, operational assumptions, and reliability, maintainability, and assessment thresholds, so the NWAC can process all fleet inputs. (Commander, NWAC, Remote, 1993, p. A3401.010)

Once users access the MRDB, they have five product selections to choose from; equipment level products, block level products, parts products, narrative products, and time meter products. After product selection, there are numerous detailed screens to analyze data from. See Appendix D for some examples of the screens and the types of information available.

Currently, the MRDB is the one source for material readiness measures, utilizing standard measurement criteria, and standardized methodology. Since its introduction in 1985,

79 equipment/systems have been added, and with more funding, other shipboard systems will be added to the MRDB. Figure 2.4 lists all the shipboard systems the Navy would like the MRDB to consist of. (Commander, NWAC, p. A3401.102)

Utilization of the MRDB helps identify design changes, compendium of fleet feedback for follow on equipment/systems, spare parts usage and supportability incurred, maintenance problems, fleet feedback through "lessons learned," and prioritization of ordered alterations (ORDALTS), spare parts, and training. The management and operation of the MRDB is crucial because its data is provided to: The CNO Readiness Improvement Program, Red Flag Systems, SEA-06 Readiness Based Sparing, OP-914 Manpower, Personnel, and Training (PM&T), SEA-06Q/PMs/ISEAs Special Requests, and SEA-06Q No Failure Evident. With such wide utilization and important decisions being based on this database, the Navy must ensure it is accurate. (Commander, NWAC, Readiness, 1993, p. B3401.055-.057)

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC MENU

EQUIPMENT LIST MENU

A10 - AN/SPY-1A PHASED ARRAY RADAR
A11 - PHASED ARRAY RADAR AN/SPY-1B
A20 - AEGIS C & D
A30 - AEGIS WCS MK 1 MOD 0
A35 - AEGIS WCS MK 1 MOD 1
A40 - AEGIS FCS MK 99 MOD 1
A45 - AEGIS FCS MK 99 MOD 2
A50 - AEGIS SFC MK 84 MOD 1
A55 - AEGIS SFC MK 84 MOD 2
A60 - AEGIS ORTS MK 1 MOD 0
A65 - AEGIS ORTS MK 1 MOD 1
A90 - VLS (CG-47 CLASS)
A91 - VLS (DD963/DDG993 CLASS)
A92 - VLS (DDG-51 CLASS)
B10 - WDS MK 14 (TERRIER)
B20 - TERRIER COMPUTER COMPLEX MOD 8
B25 - TERRIER COMPUTER COMPLEX MOD 9
B26 - TERRIER COMPUTER COMPLEX MOD 10
B30 - FC RADAR AN/SPG-55B MOD 8
B35 - FC RADAR AN/SPG-55B MOD 9
B40 - FC RADAR AN/SPG-55B MOD 10
B60 - CTS AN/SYR-1 (TERRIER)
B70 - GMLS MK 10 MODS 0-8
B80 - GMLS MK-10 SSCS
C30 - AN/SPG-51C (SM1) RADAR/DIRECTOR
C40 - AN/SPG-51D (SM2) RADAR/DIRECTOR
C90 - GMLS MK-13 MODS 4,5,7
D10 - GMLS MK 26 MODS 0-5
D25 - GMFCS MK 92 MOD 2
E10 - TAS MK 23 BLK 0
E15 - TAS MK 23 BLK 1B
E20 - NSSMS MK 57 BLOCK 0
E21 - NSSMS MK 57 BLOCK 1B
E60 - BASIC PT. DEF MFCS MK 115 MOD 0
E70 - BASIC PT. DEFENSE GMLS MK 25
F00 - AN/SAR-8 (IRSTD)
F10 - SEARCH RADAR AN/SPS-40 (FC7-SER)
F11 - SEARCH RADAR AN/SPS-40 (FC8-SER)
F13 - SEARCH RADAR AN/SPS-40E
F20 - SEARCH RADAR AN/SPS-49
F33 - SEARCH RADAR AN/SPS-52C
F60 - SEARCH RADAR AN/SPS-48C
F61 - SEARCH RADAR AN/SPS-48E
F90 - SEARCH RADAR AN/SPS-67
G20 - GMFCS MK 86
G40 - GUN TURRET 16-INCH/50
G50 - GUN SYSTEM MK 33 (MK 172 AMP)
G60 - GUN MOUNT MK 42 MOD 9
G65 - GUN MOUNT MK 42 MOD 10
G70 - GUN MOUNT MK 45 MOD 0
G75 - GUN MOUNT MK 45 MOD 1
G80 - GUN MOUNT MK 75
G90 - PHALANX MK 15 CIWS BLOCK 0
G91 - PHALANX MK 15 CIWS BLOCK 1
H10 - WSCLCS AN/SWG-1 (CANISTER)
H15 - WSCLCS AN/SWG-1 (ASROC)
H20 - WSCLCS AN/SWG-1 (TARTAR)
H25 - WSCLCS AN/SWG-1A (CANISTER)
H30 - WSCLCS AN/SWG-1A (ASROC)
H35 - WSCLCS AN/SWG-1A (TARTAR)
H50 - MK 78 MOD 1 HGMS
I30 - AN/SQS-26CX SONAR
I40 - AN/SQS-35 SONAR
I50 - AN/SQS-53A SONAR
I60 - AN/SQS-53B SONAR
I70 - AN/SQS-56 SONAR
J10 - AN/SQR-17(V)1 LAMPS MK 1 PROC.
J15 - AN/SQR-17(V)2 LAMPS MK 1 PROC.
J20 - AN/SQR-17(V)3 LAMPS MK 1 PROC.
J30 - AN/SQR-17A(V)1 LAMPS MK 1 PROC.
J35 - AN/SQR-17A(V)2 LAMPS MK 1 PROC.
J40 - AN/SQR-18A SONAR
J45 - AN/SQR-18A(V)1 SONAR
J50 - AN/SQR-18A(V)2 SONAR
J60 - AN/SQR-19 SONAR RECEIVING SET
K05 - AN/SQQ-23A SONAR SET
K06 - AN/SQQ-23B SONAR SET
K20 - AN/SQQ-28(V)2/(V)3 SONAR
K40 - AN/SQQ-28(V)4 SONAR
K50 - AN/SQQ-28(V)5 SONAR
L10 - MK 309 CONTROL PANEL
L30 - MK 116 MODS 1,5-8,10-11,13-16,23
L40 - MK 116 MODS 9 AND 12
M00 - MK 116 UFCS MOD 0
M10 - MK 116 UFCS MOD 1
M20 - MK 116 UFCS MOD 2
M30 - MK 116 UFCS MOD 3
M40 - MK 116 UFCS MOD 4
N30 - ASROC LCHR GRP MK 16 MOD 1,2
N40 - ASROC LCHR GRP MK 16 MOD 3-6
N50 - ASROC LCHR GRP MK 16 MOD 7
N60 - ASROC LCHR GRP MK 16 MOD 8
N80 - AN/SLQ-25 NIXIE
P20 - AN/SLQ-32(V)2 ECM SET
P30 - AN/SLQ-32(V)3 ECM SET
P50 - AN/WLQ-4 ECM SET
R20 - GYRO COMPASS AN/WSN-2
R30 - INERTIAL NAVSET AN/WSN-5
R40 - AN/WRN-5(V)2, 5A(V)2 RAD NAV SET
R70 - AN/SRN-18 RADIO NAVIGATION SET
R80 - [illegible]N-19 (V)2 RADIO NAV SET
S20 - AN/URN-25 (SINGLE) NAV SET TACAN
S30 - AN/URN-25 (DUAL) NAV SET TACAN
S40 - AN/URN-25 (S-STA) NAV SET TACAN
T80 - CDS (CG-16 CLASS)
T81 - CDS (CG-26 CLASS)
T83 - CDS (CGN-38 CLASS)
T84 - CDS (CVN-71 CLASS)
T85 - CDS (DDG-993 CLASS)
T88 - CDS (LHD-1 CLASS)

Figure 2.4. Systems Planned For Incorporation Into The MRDB (Commander, NWAC, Remote Access, 1993)

Unfortunately, the MRDB system has left doubts to its validity. The database is only as accurate as its most accurate inputs. From the author's fleet experience, the data that has been submitted and is being used to update the MRDB, are not exact. There are times when reports will not be submitted because the weapon system was "only down for an hour or two," and the ships crew or Commanding Officer makes the decision not to report it. However, when reported, times for delay in receipt of parts, manhours required to repair the system, and the actual time the weapon system was down are usually just estimates, not exact numbers. What is needed is simple real time data collection to ensure the validity and accuracy of fleet inputs, so that the MRDB may be accurately and efficiently utilized to base important decisions on.

By utilizing only real time data collected from ships that have qualified on the gun range, we can determine new reliability baselines for each of the weapon system's blocks (for the powder and projectile blocks, we can use data from any ship that fires the gun, not just qualifying ships). These reliability baselines can be used to form reliability block means for MTBF and repair times, whereby SPC measures can be utilized. Navy engineers, weapon system training program coordinators, logisticians and a multitude of others can use these reliability block means to judge the performance of the weapon system and identify and prioritize areas that

can be improved. Ship's Commanding Officers can use the reliability block means and resulting SPC measures to judge the performance of its crew and weapons system during drills, pacfires, or gun qualifications.

Mission time and Operational Availability calculations will only be determined by those ships that have qualified on the gun range. This is an important point. If the ship does not qualify on the gun range, she does not deploy. Only those ships that deploy will be involved in real combat missions. It is therefore extremely important to be basing high level decisions with regard to shore bombardment, call for fire, counter battery fire and a multitude of other mission profiles, on a mission time and Operational Availability calculation that is based on deployed assets whose weapon system and gun crews have proven their proficiency by previously qualifying at the gun range.

In this chapter we reviewed the terms and techniques used to measure mission time, block and system reliability, and Operational and Inherent Availability. We discussed the use of two SPC methods, control charts and Pareto analysis, to monitor the weapon system, and introduced the current system being used and the MRDB for material readiness measures. The following chapter, Methodology and Data, will illustrate the data collection and simulation programs, and how they can be utilized to accurately base decisions on.

III. METHODOLOGY AND DATA

We developed a data collection program that Comarco Engineering Support Division is currently using to gather real-time data from NGFS exercises at the United States Naval gun range on Vieques Island off Puerto Rico. This program is written in Lotus 123 Ver 2.3. The data that was collected was utilized to update an NGFS simulation. The simulation of the weapon system was then verified, and used to measure mission performance. Once a weapon system database can be written and collected data input, statistical process control procedures can be used to identify training, and engineering deficiencies. The weapon system simulation, and SPC procedures provide one method the Navy can utilize to accurately base operational, training, logistical, and engineering decisions on.

The data collection program is actually two programs wrapped in one (Figure 3.1). One part of the program is used by personnel collecting data from the ship, about the actual gun mounts and their characteristics during the NGFS exercise (Appendix E). The other part of the program is used by the spotters, on the range. This part of the program collects data pertaining to impact time, and fire control adjustments (Appendix F).

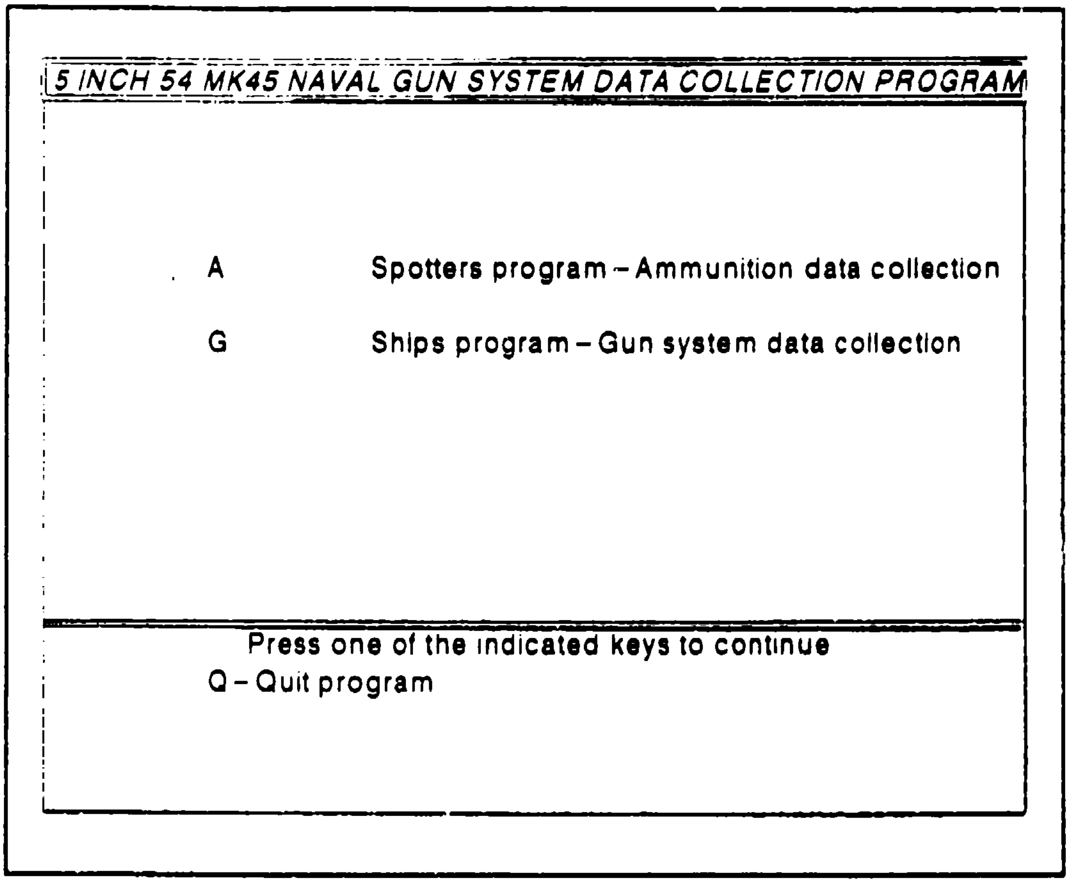

Figure 3.1. Initial Program Screen

The data collection program must be run on Lotus 123 Ver 2.3 or higher. Once the user retrieves the program, the program automatically attaches Wysiwyg, and moves to the first screen. Clearly labeled selections and screen movements highlight this program making it quick and easy to obtain real time data during a NGFS mission.

The ship's program, which collects data about the actual gun mounts, first prompts the user for the type of mission the ship will shoot. One of two mounts, mount 51 or mount 52, is then selected. The program then moves to the next screen that allows the user to input the on-station time, ready time, and/or counter battery time, and starts recording shots fired. When shots are fired, the mission shot round, time the shot was fired, cycle time between shots, mount number, and total rounds fired since the exercise began are all recorded. When a mount fails during the exercise, the user has the opportunity to shift mounts and continue with the exercise. If mounts are shifted, data such as the mission shot round, the time the mount failed, the mount number, and the block that failed is recorded for the failed mount. If at anytime during the exercise the gun mount is repaired, the user is required to record this. The time the mount was repaired and total repair time is then recorded. When the mission is completed, the program records this time. The user then has the opportunity to record the firing of another mission or end the program and record the results as a separate Lotus 123 spreadsheet in a user specified file. Figure 3.2 shows the output of a simulated exercise with three specific missions fired.

Ship – Gun Data Collection

Msn Rnd	Mission Name	Event	Time Shot	Cycle Time in Minutes	Mount Nbr	Failed Block	Time gun was Repaired	Repair time in Minutes	Rounds Fired
*	Z40G								
*		On Station	12:16:17 PM						
*		Ready	12:16:26 PM						
1			12:16:29 PM	0.03	MT 51				1
2			12:16:31 PM	0.02	MT 51				2
3			12:16:36 PM	0.05	MT 51				3
4			12:16:41 PM	0.05	MT 51				4
5			12:16:47 PM	0.06	MT 51				5
*		MisnCmpt	12:16:49 PM						
*	Z42G								
*		On Station	12:17:11 PM						
*		Ready	12:17:15 PM						
1			12:17:21 PM	0.06	MT 52				6
2			12:17:23 PM	0.02	MT 52				7
3			12:17:30 PM	0.07	MT 52				8
*		Ck_fire	12:17:45 PM						
*		Cnx_Ck_fire	12:18:00 PM						
4			12:18:03 PM	0.03	MT 52				9
5			12:18:05 PM	0.02	MT 52				10
6			12:18:11 PM	0.06	MT 52				11
*		MisnCmpt	12:18:18 PM						
*	Z43G								
*		On Station	12:18:34 PM						
*		Ready	12:18:37 PM						
1			12:18:39 PM	0.02	MT 51				12
2			12:18:44 PM	0.05	MT 51	5	12:19:10 PM	0.26	13
3			12:19:14 PM	0.30	MT 51				14
4			12:19:17 PM	0.03	MT 51				15
*		MisnCmpt	12:19:29 PM						

Figure 3.2. Output From A Simulated Exercise

The spotters data collection program collects data pertaining to impact time and the characteristics of the round fired. The initial screen allows the user to record whether the round was functional (exploded), non functional (did not explode), lost (round was unseen by spotter), hit (round hit the target) or repeat (fire same profile). Once the user makes a choice from this screen, the impact time of the round is recorded. If the round was not a lost, hit or repeat round, the spotter will radio corrections to the ship to bring the next round to be fired closer to hitting the target. These corrections for functional, and non-functional rounds are recorded as they are radioed to the ship. Corrections may include any combination of the six code words (left, right, add, drop, up, down) followed by some yardage. Figure 3.3 shows the data collected from a simulated NGFS mission using the spotter data collection program.

Spotter/Ammo Data Collection

Rnd Nbr	Function/ NonFunction	Impact Time	MPI	Left Nbr	Right Nbr	Add Nbr	Drop Nbr	Up Nbr	Down Nbr
1	Function	11:19:35 AM	223.6068	200		100			
2	Function	11:19:42 AM	25.0000	25					
3	Hit	11:19:47 AM							
4	Hit	11:19:48 AM							
5	Hit	11:19:49 AM							
6	NoNFunction	11:19:51 AM	0.0000						
7	Hit	11:19:58 AM							
8	Hit	11:19:59 AM							
9	Function	11:20:03 AM	25.0000			25			
10	Hit	11:20:10 AM							
11	Hit	11:20:11 AM							
12	NoNFunction	11:20:13 AM	25.0000			25		25	
13	Function	11:20:24 AM	0.0000						50
14	Report	11:20:36 AM							
15	Hit	11:20:37 AM							
16	Hit	11:20:38 AM							
17	Hit	11:20:40 AM							
18	Hit	11:20:41 AM							
19	Lost	11:20:43 AM							

Figure 3.3. Spotter Program Simulated Output

Information from the data collection program pertaining to ships information, the gun system, and ammunition, is then input into the weapon system database. The database is used to update the reliability of the fifty five blocks that comprise the 5" 54 MK 45 gun system. Currently, the data collection program, database, and simulation program do not "talk", so information must be input from one program's results to the next program. The simulation is then run

repeatedly in order to come up with statistically valid results.

The simulation program was developed at NPS. In order to validate the simulation program of the weapon system, the program was loaded with one specific mission profile. The mission is a Marine Corps scenario which requires the Navy, utilizing NGFS, to destroy eighteen targets in a specified amount of time. The simulation was run a number of times to come up with an accurate, simulated, mission time. Once the simulation program has been validated, other NGFS scenarios and mission profiles may be input into the simulation program, in order to accurately predict mission times for those specific NGFS scenarios. Currently, the weapon system simulation program has proven extremely accurate compared to the results obtained during real NGFS missions. The accuracy of the simulation is very important and will play a key role in the cost savings analysis.

In order to spend our money wisely, decreasing mission time with the least amount of money, we will utilize a SPC method, the Pareto analysis chart. With the use of a Pareto analysis chart, we can decide which weapon system block failed the most and should be analyzed for further modification. Modifications could have included the re-engineering of specific components of the block or modifications to the gun system to make the block easier to repair. Then, by using the

weapon system simulation program, we can analyze the cost for modification, to the savings in mission time.

By investing money in the modification of a specific weapon system block, we gain an anticipated MTTR and conditional probability based on its estimated failure percentage. These figures are input into the weapon system simulation program. The simulation program is then run several times to gain a new simulated mission time. Engineers and the weapon system program manager can analyze the new simulated mission time and the cost to achieve it and decide whether to invest the money or look for a different alternative to improve the Operational Availability of the gun system and decrease its mission time.

The database can also be used to draw control charts pertaining to MTTR and MRBF for each of the weapon systems blocks. These control charts become great tools to a ships Commanding Officer and weapon system engineers. By plotting each failure and time to repair on the block specific control chart, we can quickly and easily determine if the gun system is in or out of control. If the gun system is determined to be out of control, the failure can be analyzed and a special cause determined. Special causes may be a poorly trained gun crew, or a gun system that has not been fully "groomed" for action. In any case, block specific control charts provide a quick and easy way to analyze the gun shoot.

A weapon system simulation and SPC methods are powerful tools that can be used to increase Operational Availability, and decrease mission time. Why spend thousands or millions of dollars modifying a weapon system block if we do not decrease our mission time? Or, if we do decrease the mission time, how much money should we spend for each second or minute, and is it really worth the money? These are questions for the engineers and program managers to answer.

In this chapter we reviewed and discussed the benefits of the real time data collection and simulation programs. We followed with two SPC methods that can be utilized to help determine the best way to decrease mission time with what money may be available to the program manager. The following chapter, Analysis of Collected Data, illustrates and analyzes simulated data collected via the real time data collection program, and other data collection means. Specific data is then used to update the simulation program which is run for three different NGFS missions and the simulated results are then compared to real NGFS missions. Control charts and Pareto analysis charts are then created utilizing the collected data, and their benefits discussed.

IV. ANALYSIS OF COLLECTED DATA

A large portion of the data that will be analyzed was collected by Comarco Engineering Support Division from April 1991 through April 1993. This data was collected by means of paper and pen, and ships and spotter operating sheets, not the newly created program via Lotus 123.

From April 1991 through April 1993, fifty Navy ships were scheduled for data collection. Of the fifty ships, four aborted prior to shooting, and two aborted during qualification. Because it does not matter which gun fires the 5" projectiles, (5" 54 MK 45 Mod 0, Mod 1, or 5" MK 42) the remaining forty four ships were used to calculate reliability figures for the projectile, and powder blocks.

Appendix G shows the data that was collected and combined for the forty four ships. Of the 5027 rounds fired, there were 9 powder delays. This led to a powder block failure rate of .179%. Of the 5027 rounds fired, 2270 were HE (high explosive) of which there were 48 HE duds (rounds that failed to explode), 2241 were puff (dummy) of which 46 were duds, and 516 were star (illumination) of which 80 were observed to have delays. This led to a HE projectile failure rate of 2.115%, a puff projectile failure rate of 2.053%, and a star projectile failure rate of 15.504%.

Of the forty four ships, six fired spotter exercises vice firing for qualification. Of the thirty eight ships that fired for qualification, thirty five were 5" 54 MK 45 shooters. Of those thirty five ships, only twenty eight of them fired for qualification. The other seven ships either aborted during the gun shoot, or were scheduled to shoot for modified qualifications. Of these twenty eight ships scheduled to shoot for full qualification, data from 14 of the ships was collected on the ship and at the observation post.

Appendix H shows the fourteen ships from which data was collected, the number of rounds fired, the total number of gun failures observed, the failed blocks MTTR and the failed block percent of failures. Unfortunately, ship specific data sheets could not be obtained and analyzed to come up with which ship had what gun failure, and exact repair times for block repair rates. Although it would have been nice to be able to work with the exact numbers obtained through the observations, it is not terribly important, the methodology is the same. We have filled in the gaps of missing data with some of our own.

Using the data collected from the fourteen ships, we can now begin to draw some fundamental conclusions about the 5" 54 MK 45 gun system. We can draw these conclusions because we know the data has been collected from those ships that have qualified during NGFS exercises. These ships have proven that their 5" 54 MK 45 gun system and its crew are ready to deploy.

These ships will be the ones chosen to fight first and thus should give us the best information from which we can base decisions about predicting mission time, and re-engineering or improving specific block reliabilities in order to lower mission time.

The Pareto analysis chart, Figure 4.1, shows the beginning of a pattern. The fuse setter, block number 5, has failed eight times during the 1219 rounds fired. MTTR this type of gun failure has been 920 seconds or a little over 15 minutes. Navy engineers can use this data to study block 5 of the weapon system to determine what part is failing and why it is failing. Then, by determining how much it would cost to correct the problem or at least increase the overall reliability of the block, we can plug the newly anticipated block 5 reliability figures into the weapon system simulation model and determine how much of a decrease in mission time we obtain, and calculate the increased gun system and block reliabilities. The weapon system program manager can then determine whether it is worth spending the money correcting the deficiency found in block 5.

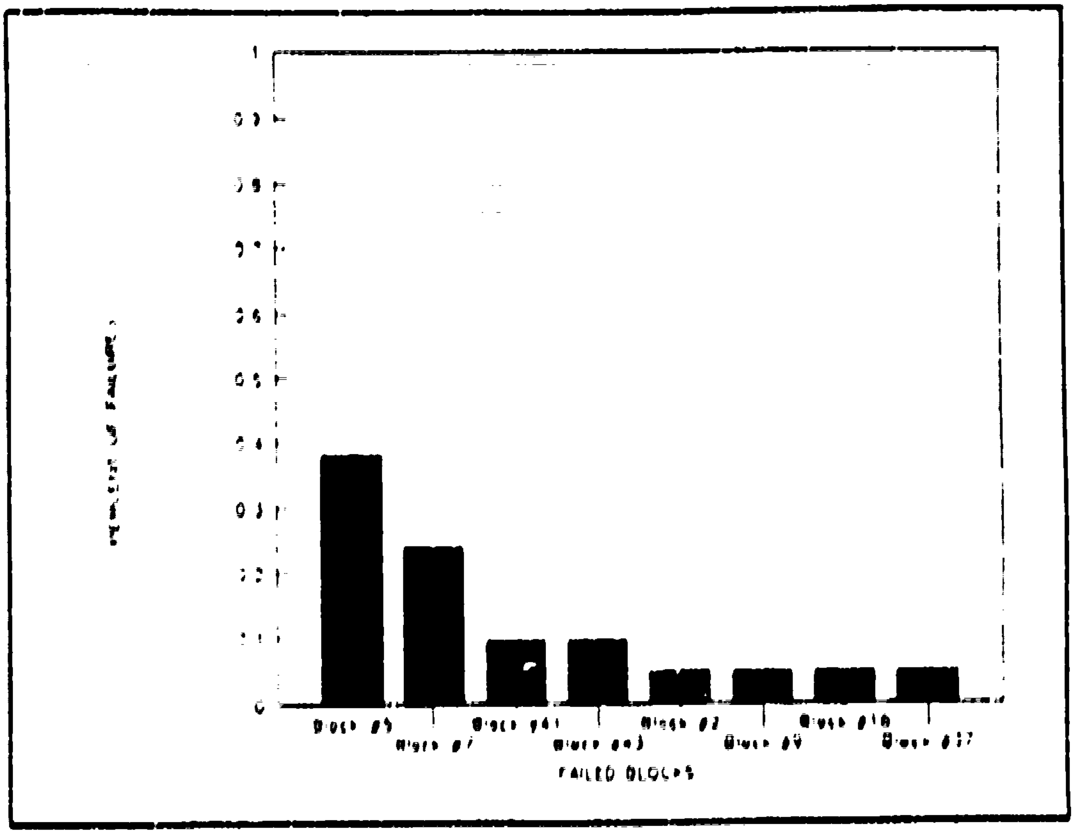

Figure 4.1. Pareto Analysis Of Collected Data

The weapon system simulation is an extremely important part of our analysis. Without it we would have to spend the money on improving the deficiency found in block 5 and then go and collect more data to see if it was effective in decreasing mission time and by how much. This of course takes time. The weapon system simulation allows us to make intelligent decisions based on a model without spending any money. The key to the weapon system simulation is proving its accuracy.

We used the data collected from nine of the fourteen ships to analyze the accuracy of the weapon system simulation program. These nine ships fired the same three missions and therefore yielded the average mission times listed below.

SHIP NAME	**MISSION TYPE AND TIME IN SECOND**		
	Z-40-G	**Z-42-G**	**Z-43-G**
USS STUMP	643	667	337
USS GETTYSBURG	423	842	332
USS BRISCOE	349	633	329
USS HUE CITY	567	558	338
USS O'BANNON	261	547	390
USS MOOSBRUGGER	455	449	196
USS PETERSEN	247	469	283
USS HAYLER	195	405	381
USS VIRGINIA	511	845	339
AVERAGE TIME	458	601	325

Z-40-G AVERAGE MISSION TIME = 7 Min 38 Seconds
Z-42-G AVERAGE MISSION TIME = 10 Min 1 Second
Z-43-G AVERAGE MISSION TIME = 5 Min 25 Seconds

(Comarco, 1993, pp. 1-10)

The weapon system simulation was updated using the data from Appendix G and Appendix H, and run for each of the three missions listed; Z-40-G, Z-42-G and Z-43-G. Appendix I illustrates the weapon system simulation output and average mission times obtained. As you can see from the combined data below:

MISSION	ACTUAL MISSION TIME	SIMULATED MISSION TIME
Z-40-G	7 Min 38 Seconds	7 Min 13 Seconds
Z-42-G	10 Min 1 Second	10 Min 0 Seconds
Z-43-G	5 Min 25 Seconds	5 Min 47 Seconds

The weapon system simulation program proved to be extremely accurate in predicting mission time. (Comarco, 1993, pp. 11-14)

Control charts are a real quick and easy way to analyze a gun shoot. The real users of the control charts would be the operators; the ship's crew. Although data has been collected on fifty percent of the available assets scheduled for data collection, 14 of 28 ships, we do not currently have enough data available to accurately produce control charts for MTTR and MRBF for any of the fifty five blocks. In order to discuss control charts we will take some liberties with the data from Appendix H.

Figures 4.2 and 4.3 are examples of MTTR and MRBF control charts for block 5, the fuse setter. Due to the lack of collected data, we have given the control charts some arbitrary means, and upper and lower bounds based on the three sigma rule. For our purposes, a sample or observation is an observed failure. As the control chart reveals, seven of the eight repair times recorded were within our control limits. The second observed failure took 1060 seconds to repair. This plots above the upper control limit and is therefore flagged as a potential problem. The ship's Weapons Officer would then be interested in investigating the cause for this excessive repair time. By using the three sigma rule, we will be saying that there is a (100%-99.73%) or .27% likelihood that this

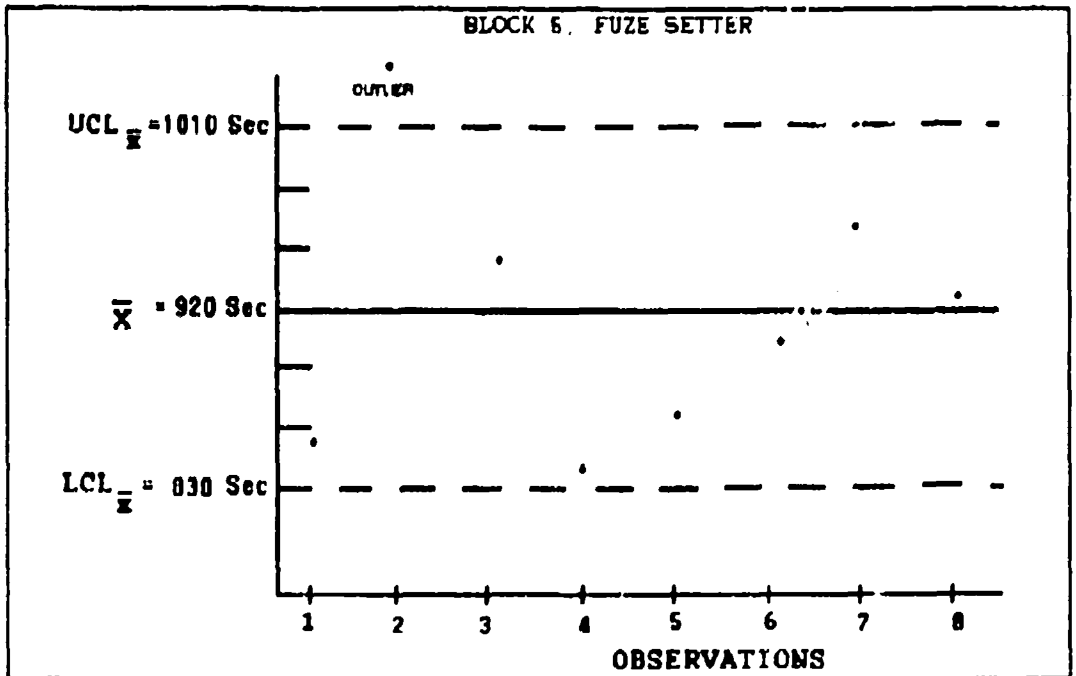

Figure 4.2. Mean-Time-To-Repair Control Chart

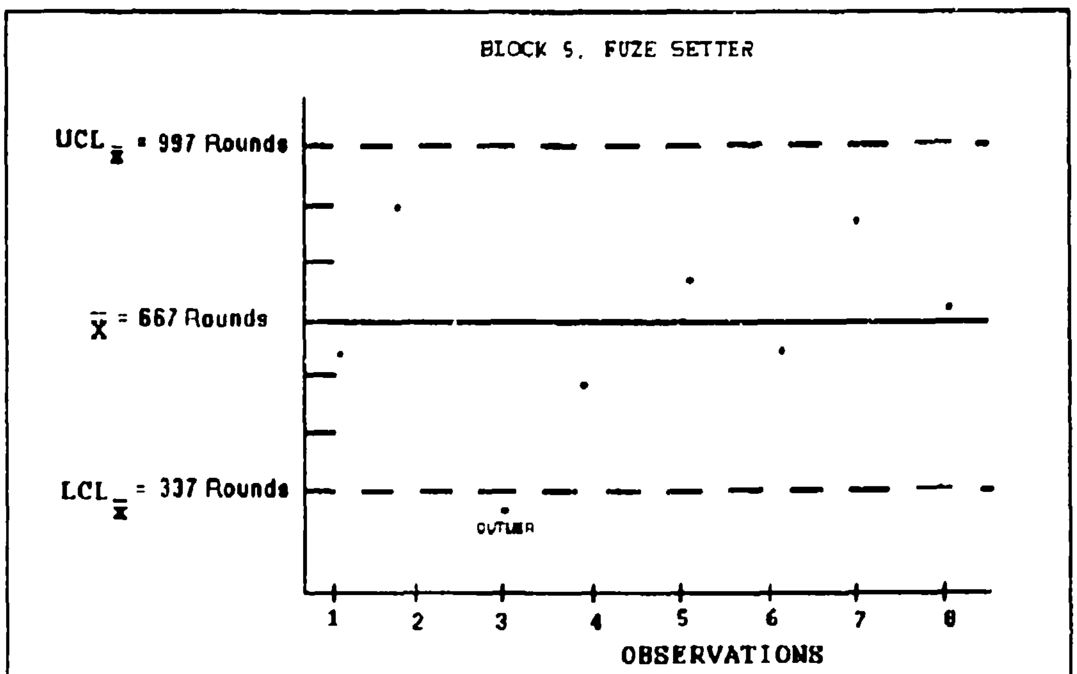

Figure 4.3. Mean-Rounds-Between-Failure Control Chart

excessive repair time occurred entirely by chance, and a 99.73% chance that it was caused by a non-random, assignable cause. By investigating, the Weapons Officer may find out that the crew is not properly trained, or that the proper tools were not onhand for the repair. These problems can then be addressed and corrected, thereby decreasing the ships mission time.

Figure 4.3 is an example of a MRBF control chart for block 5, the fuse setter. Because we were unable to review the original data, we could not accurately come up with the rounds between each fuse setter error, so we chose some arbitrary numbers which have been plotted on the control chart. As can be seen, one of the observations plotted outside of the lower control limit.

Once again using the three sigma rule, there is a .27% chance that this observation was by pure randomness and therefore will be investigated for special or assignable causes. The Leading Petty Officer may find that there is a worn part in the fuse setter assembly that is causing the weapon system to go down due to a block 5 failure more often than is the norm. The part could then be replaced, restoring the weapon system back to a predictable state.

In this chapter we illustrated and analyzed simulated data collected via the real time data collection program, and other data collection means. Specific data was used to update

the simulation program which was then run for three different NGFS missions and the simulated results were then compared to real NGFS mission times. Control charts and Pareto analysis charts were then created utilizing the collected data, and their benefits discussed. The following chapter, Conclusions and Recommendations, summarizes the thesis, and makes suggestions for further research.

V. CONCLUSIONS AND RECOMMENDATIONS

The objective of this thesis was to show that a tool such as Lotus 123 could be utilized to write an accurate real time data collection program and combined with a simulation of the 5" 54 MK 45 gun system, enhance Operational Availability and decrease mission time.

By collecting data on block failures, and the time it takes to repair them, we can construct a very accurate weapon system database. Statistical Process Control methods could then be used to analyze the database to identify training, mechanical problems, and engineering deficiencies within a specific block of the weapon system. By utilizing the weapon system database, we could update the 5" 54 MK 45 weapon system simulation program to analyze the best possible solutions for the least amount of money.

We were successful in developing a real time data collection program written in Lotus 123 that is currently being used to collect data from the fleet. This program has made real time data collection easier and more accurate. Future program development will see the data collection program written in executable code, complete with a detailed instruction manual. The program will also combine the gun and spotter program into one program in order to allow for just

one observer on the ship, alleviating the need for another observer at the gun range.

As of April 1993, prior to the development of the data collection program, data was collected from over forty-four ships. From these data sheets the 5" 54 MK 45 weapon system simulation program was updated and tested. The weapon system simulation program was programmed to simulate three different NGFS scenarios, and run five replications. The weapon system simulation program proved to be an extremely accurate representation of these three NGFS mission scenarios.

With an accurate real time data collection method and simulation of the weapon system, we are in a position to analyze solutions to problems we see in the 5" 54 MK 45 weapon system. Unfortunately, a database has not been developed to combine the data collected, but we understand that the development of a database is underway at Crane Naval Surface Weapons Center (Callahan, 1993). Current data that has been collected is awaiting input into such a database, whereby SPC methods could be utilized to enhance the abilities of Navy logisticians and engineers in the identification of problems with the weapon system. The simulation program could then be used to analyze potential solutions to determine if modifying a specific block or component, increasing repair training on a block, or a multitude of other options will significantly

decrease the mission time to be worth the expenditure of the money.

The methodology presented in this thesis allows us to make more informed and accurate decisions with regard to the expenditure of money on the 5" 54 MK 45 weapon system. This methodology could easily be expanded to most other weapon systems and could lead to better use of Navy funds, greater Operational Availability, and lower mission times.

Further research in this field could be beneficial in the following areas:

1. Create a non-human way to collect data. This could be done by placing sensors on each block of a weapon system to record failures and repair times. This would alleviate the need for crew or outside observer participation in the collection of data. (Callahan, 1993)

2. Provide the fleet with control charts for block failures and Mean-Time-To-Repair block failures, in order to help the surface units analyze their NGFS missions, and take appropriate actions with regards to deficiencies. This could be expanded into a form of total quality management and be a very useful tool to the fleet.

APPENDIX A

LIST OF ABBREVIATIONS

CASREP	Casualty Reporting
CO	Commanding Officer
MRBF	Mean-Rounds-Between-Failures
MRDB	Material Readiness Data Base
MTTR	Mean-Time-To-Repair
NGFS	Naval Gun Fire Support
NPS	Naval Postgraduate School
NWAC	Naval Warfare Assessment Center
ORDALTS	Ordered Alterations
RMA	Reliability, Maintainability, and Availability
SPC	Statistical Process Control
SPCC	Ships Parts Control Center

APPENDIX B

5" 54 MK 45 MOD 0 GUN SYSTEM RELIABILITY BLOCK NAMES

1. LOWER ACCUMULATOR SYSTEM
2. LOWER HOIST ASSEMBLY
3. LOADER DRUM ASSEMBLY
4. UPPER HOIST ASSEMBLY
5. FUSE SETTER ASSEMBLY
6. UPPER ACCUMULATOR ASMBLY
7. CRADLE AND RAMMER ASMBLY
8. GUN BARREL HOUSING ASMBLY
9. BREECH MECHANISM
10. RECOIL COUNTERRECOIL SYSTEM
11. EMPTY CASE TRAY ASSEMBLY
12. EMPTY CASE EJECTOR ASSEMBLY
13. GUN BARREL ASSEMBLY
14. SLIDE ASSEMBLY
15. ELEVATION POWER DRIVE
16. TRAIN POWER DRIVE
17. ELEVATION RECEIVER REGULATOR
18. TRAIN RECEIVER REGULATOR
19. ELECTRONIC SERVO CONTROL UNIT
20. STAND
21. CARRIAGE
22. SHIELD
23. 440V 60 HZ POWER
24. 115V 60 HZ POWER
25. 115V 60 HZ FIRING SUPPLY
26. 115V 60 HZ LIGHTING SUPPLY
27. 115V 400 HZ SYNCHRO SUPPLY
28. 24VDC BATTERY CHARGING CIRCUIT
29. 26VDC POWER SUPPLY
30. +25V SOLENOID SUPPLY CIRCUITS A&B
31. +25V SWITCH SUPPLY CIRCUITS A&B
32. +25V SWITCH AND LOGIC SUPPLY CIRCUIT
33. +25V PUSHBUTTON SUPPLY CIRCUIT
34. +25V CONTACTOR SUPPLY CIRCUIT
35. +25V LIGHT SUPPLY CIRCUIT
36. +25V LOGIC SUPPLY CIRCUIT
37. +28V WEAPONS CONTROL INFORMATION
38. +5VDC POWER SUPPLY
39. EP3 PANEL
40. ANTI-ICING SYSTEM (NME)
41. BLOWER MOTOR
42. EP1 PANEL/CABLING
43. EP2 PANEL/CABLING
44. EP3 PANEL CABLING
45. EBX1 CABLING AND CONNECTIONS
46. EBX2 CABLING AND CONNECTIONS
47. EBX3 CABLING AND CONNECTIONS
48. EBX4 CABLING AND CONNECTIONS
49. EBX5 CABLING AND CONNECTIONS
50. EBX6 CABLING AND CONNECTIONS
51. EBX7 CABLING AND CONNECTIONS
52. EBX8 CABLING AND CONNECTIONS
53. EBX9 CABLING AND CONNECTIONS
54. POWDER
55. PROJECTILE

APPENDIX C

EQUATIONS FOR OPERATIONAL AND INHERENT AVAILABILITY

Ao	- OPERATIONAL AVAILABILITY
Ai	- INHERENT AVAILABILITY
MTBF	- MEAN TIME BETWEEN FAILURES
MDT	- MEAN DOWN TIME
MDTs	- MEAN DOWN TIME SCHEDULED
MDTu	- MEAN DOWN TIME UNSCHEDULED
MDToa	- MEAN DOWN TIME DUE TO OUTSIDE ASSISTANCE
MDTops	- MEAN DOWN TIME DUE TO OPERATIONS
MDTd	- MEAN DOWN TIME DUE TO DELAY
MTTR	- MEAN TIME TO REPAIR
MLDT	- MEAN LOGISTICS DELAY TIME
MLT	- MEAN LOGISTICS TIME
MoaDT	- MEAN OUTSIDE ASSISTANCE DELAY TIME
MoaT	- MEAN OUTSIDE ASSISTANCE TIME
UF	- USAGE FACTOR
Tm	- ENERGIZED TIME
N	- NUMBER OF FAILED EVENTS
D	- DOWN TIME
Nm	- NUMBER OF MEASURED EVENTS
Cm	- CORRECTIVE MAINTENANCE TIME
LOG	- LOGISTICS TIME
OA	- TIME WAITING FOR OUTSIDE ASSISTANCE
NL	- NUMBER OF LOGISTICS DELAYS
Noa	- NUMBER OF OUTSIDE ASSISTANCE DELAYS

$$Ao=(MTBF+UF)+((MTBF+UF)+MDT)) \qquad Ai=(MTBF\div UF)\div((MTBF\div UF)$$

$$MTBF=Tm\div N \qquad MDT=D\div Nm \qquad MTTR=Cm+Nm$$

$$MoaT=OA+Noa \qquad MoaDT=OA+Nm \qquad MLDT=LOG+Nm$$

$$MLT=LOG+NL$$

APPENDIX D

EXAMPLES FROM REMOTE ACCESS PRODUCTS SCREENS

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC

PRODUCTS

REMOTE ACCESS PRODUCTS

- EQUIPMENT LEVEL PRODUCTS (A SCREENS)
- BLOCK LEVEL PRODUCTS (B SCREENS)
- PARTS PRODUCTS (C SCREENS)
- NARRATIVE PRODUCTS (D SCREENS)
- TIME METER PRODUCTS (E SCREENS)

REV1291

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NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

EQUIPMENT LEVEL INFORMATION

SCREEN INDICATOR	EQUIPMENT LEVEL PRODUCT
A1X	EQUIPMENT LEVEL READINESS INDICES
A2X	EQUIPMENT LEVEL INDICES BY SHIP CLASS
A3X	EQUIPMENT LEVEL INDICES BY SHIP
A4X	EQUIPMENT LEVEL INDICES BY SHIP & SERIAL NUMBER

WHERE X IS SUBSTITUTED BY:

O - OBSERVED DUTY FACTOR

P - PROGRAM MANAGER SPECIFIED DEMAND FACTORS

A - 100% USE FACTORS

U - USER SELECTED USE FACTORS

REV1291 A3401.108

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

EQUIPMENT LEVEL INDICES (A1P)

EQUIPMENT LEVEL PRODUCTS

1 - EQUIPMENT LEVEL INDICES

```
04/14/89 09:31         OP-03 MATERIAL READINESS DATA BASE
                              EQUIPMENT LEVEL INDICES
EQUIPMENT MK XXX MOD 1                 FROM 870101 TO 871231 SERIAL ALL
  CRITICALITY   SHIP STATUS   MODES   FLEET   SHIP CLASS HULL/UIC
   CR            ALL           A       ALL     ALL

 CALCULATED USING PROGRAM MANAGER SPECIFIED DEMAND FACTORS

 OPERATIONAL AVAILABILITY        0.83   MEAN LOGISTIC DELAY TIME         134.4
                                        MEAN LOGISTIC TIME               487.2
 INHERENT AVAILABILITY           0.99   LOGISTIC DELAY RATIO              0.28
                                        MEAN OUTSIDE ASST DELAY TIME      14.8
 MEAN TIME BETWEEN FAILURES     816.2   MEAN OUTSIDE ASSISTANCE TIME     306.2
                                        MEAN DOWNTIME                    164.9
 MEAN TIME TO REPAIR              5.6
                                        MAINTENANCE INDEX                 0.01
                                        LOGISTIC INDEX                    0.16

 NOTE:  INDICES BASED UPON FEW BLOCK EVENTS MAY NOT BE OF STATISTICAL VALUE.
        REFER TO BLOCK PRODUCTS 5 AND 6 FOR SUMMARY BLOCK INFORMATION.

                 (PR)INT      (ME)NU      (HE)LP      (EX)IT
>
```

REV1291 A3401.068

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

EQUIPMENT LEVEL INDICES BY SHIP AND SERIAL NUMBER (A2P)

EQUIPMENT LEVEL PRODUCTS

1 - EQUIPMENT LEVEL INDICES

2 - EQUIPMENT LEVEL INDICES BY SHIP AND SERIAL NUMBER

```
                         **** FOR OFFICIAL USE ONLY ****
11/25/91 10:51         OP-03 MATERIAL READINESS DATA BASE
                 EQUIPMENT LEVEL INDICES BY SHIP AND SERIAL NUMBER
                          SPS 55 FROM 900101 TO 901231
  CRITICALITY   SHIP STATUS   MODES   FLEET   SHIP CLASS HULL/UIC
     CR,MJ          ALL         A      ALL     ALL
 CALCULATED USING PROGRAM MANAGER SPECIFIED DEMAND FACTORS
  UIC/HULL    SERIAL NO     UIC/HULL    SERIAL NO     UIC/HULL    SERIAL NO
  AE    28  582             AE    28  583             AE    32  590
    AO              0.88      AO              0.54      AO              0.75
    AI              1.00      AI              0.92      AI              1.00
    MTBF           890.0      MTBF           310.0      MTBF          1200.0
    MTTR             2.2      MTTR            26.0      MTTR             0.6
    MLDT           120.0      MLDT           130.0      MLDT           390.0
    MLT            260.0      MLT            280.0      MLT            620.0
    LDR             0.45      LDR             0.47      LDR             0.62
    MOADT            0.0      MOADT           38.0      MOADT            0.0
    MDT            120.0      MDT            270.0      MDT            390.0
    MI              0.00      MI              0.08      MI              0.00
    LI              0.13      LI              0.43      LI              0.34
 NOTE:  INDICES BASED UPON FEW BLOCK EVENTS MAY NOT BE OF STATISTICAL VALUE.
                          **** FOR OFFICIAL USE ONLY ****
    (PR)INT     ( ) OR (MO)RE     (ME)NU     (PRE)V-DATA     (HE)LP     (EX)IT
```

REV1291

A3401.109

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

BLOCK LEVEL INFORMATION

SCREEN INDICATOR	BLOCK LEVEL PRODUCT
B1	RELIABILITY BLOCK AVAILABILITY INDICES
B2	RELIABILITY BLOCK MEAN TIME BETWEEN FAILURES
B3	RELIABILITY BLOCK MAINTAINABILITY INDICES
B4	RELIABILITY BLOCK LOGISTIC INDICES
B5	RELIABILITY BLOCK DOWNTIMES
B6	RELIABILITY BLOCK FAILURE COUNTS
B7	RELIABILITY BLOCK DOWNTIMES BY EVENT
B8	REL BLOCK AVAILABILITY INDICES BY SHIP & SERIAL NO.
B9	REL BLOCK MEAN TIME BETWEEN FAILURES BY SHIP & SERIAL NO.
B10	REL BLOCK MAINTAINABILITY INDICES BY SHIP & SERIAL NO.
B11	REL BLOCK LOGISTIC INDICES BY SHIP AND SERIAL NO.
B12	MISCELLANEOUS SUMMARY BLOCK & SYSTEM INFORMATION
B13	BLOCK LEVEL INFORMATION (LOCAL USER OPTION)
B14	RELIABILITY BLOCK DOWNTIMES & PARTS BY EVENT

REV 12/91

A3401.112

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

RELIABILITY BLOCK AVAILABILITY INDICES (B1)

BLOCK LEVEL PRODUCTS

1 – RELIABILITY BLOCK AVAILABILITY INDICES

```
04/14/89 09:32          OP-03 MATERIAL READINESS DATA BASE
                       RELIABILITY BLOCK AVAILABILITY INDICES
                    MK XXX MOD 1     FROM 870101 TO 971231 SW ALL
  CRITICALITY    SHIP STATUS    MODES    FLEET    SHIP CLASS HULL/UIC
    CR              ALL           A        ALL      ALL
SORT BY:
```

RELIABILITY BLOCK	AO	AO LCL	AI	AI LCL
LIQUID COOLER	0.97	0.94	1.00	1.00
MK 55 MOD 0 STIR ANTENNA	0.99	0.91	1.00	1.00
SDC COMPUTER	0.91	0.83	1.00	1.00
RIGHT ELEVATOR	1.00	1.00	1.00	1.00
POWER SUPPLIES (STANDBY)	0.96	0.94	1.00	1.00
CONTROL MONITOR (PWR)	1.00	-----	1.00	-----
BEAMFORMER	1.00	1.00	1.00	1.00
ANTENNA ARRAY SERIAL COMPONENTS	1.00	-----	1.00	-----
BREECH MECHANISM	0.97	0.95	1.00	1.00
ELECTRICAL COMPONENTS A-RAIL	0.99	0.98	1.00	1.00
GUN LAYING	1.00	1.00	1.00	1.00

```
(PR)INT   (MO)RE   (ME)NU   (PRE)V-DATA   (SO)RT   (HE)LP   (EX)IT

>
```

REV1291 A3401.869

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

RELIABILITY BLOCK MEAN TIME BETWEEN FAILURES (B2)

BLOCK LEVEL PRODUCTS

1 – RELIABILITY BLOCK AVAILABILITY INDICES

2 – RELIABILITY BLOCK MEAN TIME BETWEEN FAILURES

```
04/14/89 09:33        OP-03 MATERIAL READINESS DATA BASE
                  RELIABILITY BLOCK MEAN TIME BETWEEN FAILURE
                 MK XXX MOD 1     FROM 870101 TO 871231 SW ALL
  CRITICALITY    SHIP STATUS   MODES   FLEET   SHIP CLASS HULL/UIC
   CR            ALL           A        ALL     ALL
SORT BY:

  RELIABILITY BLOCK                                  MTBF        MTBF
                                                                  LCL
LIQUID COOLER                                        6250.9      4417.3
MK 55 MOD 0 STIR ANTENNA                            88912.3     22858.2
SDC COMPUTER                                         3663.5      2320.9
RIGHT ELEVATOR                                       4212.5      2270.9
POWER SUPPLIES (STANDBY)                             2790.3      2175.4
CONTROL MONITOR (PWR)                               21062.6      9147.3
MEANPOWNER                                          37673.7     16917.3
ANTENNA ARRAY SERIAL COMPONENTS                     88912.3     38614.1
BREECH MECHANISM                                     5200.4      3781.1
ELECTRICAL COMPONENTS A-RAIL                        12325.0      7808.3
GUN LAYING                                          34301.3     12889.6

* - MEAN ROUNDS BETWEEN FAILURES, ** - MEAN CYCLES BETWEEN FAILURES
     (PR)INT   (MO)RE   (ME)NU   (PRE)V-DATA   (SO)RT   (HE)LP   (EX)IT

>
```

BEV1281 A3401.070

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

PARTS PRODUCTS

SCREEN INDICATOR	PARTS PRODUCT
C1	PART LOGISTIC DELAY INFORMATION
C2	PART ACTION WITH DATE OF ACTION
C3	PART RELIABILITY INDICES
C4	PART ACTION BY SHIP AND RELIABILITY BLOCK
C5	PART ACTION BY RELIABILITY BLOCK
C6	PART ACTION WITH DATE OF ACTION SORTED ON PART-ID
C7	PART REL INDICES SORTED ON NUMBER REPLACED
C8	PART REL INDICES SORTED ON TOTAL ACTIONS
C9	PART LOGISTIC DELAY INFO SORTED ON HULL & SERIAL NO.
C10	PART ACTION BY SHIP & REL BLOCK SORTED ON BLOCK & PART ID
C11	"ENHANCED" PART LOGISTIC DELAY INFORMATION
C12	"ENHANCED" PART ACTION
C13	SUPPORTABILITY DRIVERS
C14	RELIABILITY DRIVERS
C15	MAINTENANCE DRIVERS
C16	COST DRIVERS (LOCAL USER OPTION)

REV 1291 A3401.116

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

PART LOGISTIC DELAY INFORMATION (C1)

PARTS PRODUCTS

→ 1 – PART LOGISTIC DELAY INFORMATION

```
04/14/89 09:36          OP-03 MATERIAL READINESS DATA BASE
                          PART LOGISTIC DELAY INFORMATION
                  MK XXX MOD 1    FROM 870101 TO 871231 SN ALL
  CRITICALITY    SHIP STATUS    MODES    FLEET    SHIP CLASS HULL/UIC
   CR              ALL          A         ALL      ALL
SORT BY:
  UIC/HULL     PART-ID                 QTY      NIIN     DATE     DATE    LOGISTIC PART
  SERIAL #     PART NUMBER/NAME                        ORDERED RECEIVED  DELAY    CRIT

  DO    982    10A10A1A3                001               870706   870724    431.0    4
22

  DO    974    10A10A2AR1               001               870518   870522     89.2    4
17

  DO    978    10A11                    001               871015   871030    357.0    4
19

  DO    982    10A11PS1                 001               870706   870724    431.0    4
22

    (PR)INT  (MO)RE  (ME)NU  (PRE)V-DATA  (SO)RT  (HE)LP  (EX)IT  (SE)ARCH

>
```

REV1291 A3081882

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC PRODUCTS

PART ACTION WITH DATE OF ACTION (C2)

PARTS PRODUCTS

1 – PART LOGISTIC DELAY INFORMATION

2 – PART ACTION WITH DATE OF ACTION

```
04/14/89 05:36          OP-03 MATERIAL READINESS DATA BASE
                          PART ACTION WITH DATE OF ACTION
                   HE XXX MOD 1    FROM 870101 TO 871231 SR ALL
  CRITICALITY  SHIP STATUS   MODES   FLEET   SHIP CLASS HULL/UIC
   C?            ALL          A       ALL     ALL
SORT BY:
   UIC/HULL       PART-ID              COG    NIIN         ACTION    ACTION    PART
   SERIAL #       PART NUMBER/NAME                          TAKEN     DATE      CRIT

   DD   964       7A2A1A30                    000000000    REPLACED  870130     4
 2
   DD   964       7A2FL1                      000000000    REPLACED  870215     4
 2
   DD   965       7A1A15                      000000000    REPLACED  870202     4
 3
   DD   965       10A10A2                     000000000    REPLACED  870116     4
 3

   (PR)INT  (MO)RE  (ME)NU  (PRE)V-DATA  (SO)RT  (HE)LP  (EX)IT  (SE)ARCH
  >
```

REV1291

A3401.083

NARRATIVE PRODUCTS

SCREEN INDICATOR	NARRATIVE PRODUCT
D1	NARRATIVE WITH PART, ACTION TAKEN & REL BLOCK
D2	NARRATIVE WITH RELIABILITY BLOCK

REV1291

A3401.093

NARRATIVE WITH PART, ACTION TAKEN, & REL BLOCK (D1)

NARRATIVE PRODUCTS

1 – NARRATIVE WITH PART, ACTION TAKEN, & REL BLOCK

```
                        **** FOR OFFICIAL USE ONLY ****
09/07/89 14:23        OP-03 MATERIAL READINESS DATA BASE
            NARRATIVE WITH PART, ACTION TAKEN, AND RELIABILITY BLOCK
                 AN/SLQ-XX  FROM 880401 TO 890331 SN ALL
  CRITICALITY   SHIP STATUS   MODES   FLEET   SHIP CLASS HULL/UIC
   CR,MJ         ALL           B       ALL     ALL

        USS KINKAID (DD 965)              HULL NUMBER DD   965   SN A39
                          SHIP STATUS:                            FLEET
                  EVENT START: 890121      EVENT END: 890122
 CM:      23.3  LOG:        0.0  OA:       0.0  ADM:       0.0   TOT:       23.3
              NARRATIVE
  SLQ-XX HAS REDUCED CAPABILTY DUE TO AMPLIFIER NUMBER ONE
HAVING INTERMITTENT LOSS OF HIGH FREQ CAPABILTY XXX ORDER AND
REPLACE AMPLIFIER NUMBER ONE
        PART-ID        ACTION           RELIABILITY BLOCK
 2A2                   REP      U2A2 POWER AMPLIFIER (2A2)


NEXT NARRATIVE(NN) SCROLL NARRATIVE UP(NU) DOWN(ND) SCROLL PART UP(PU) DOWN(PD)
              (PR)INT     (ME)NU     (SO)RT     (HE)LP     (EX)IT
```

REV1291

A3401.094

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

NARRATIVE WITH RELIABILITY BLOCK (D2)

NARRATIVE PRODUCTS

1 – NARRATIVE WITH PART, ACTION TAKEN, & REL BLOCK

2 – NARRATIVE WITH RELIABILITY BLOCK

```
09/07/89 14:27        OP-03 MATERIAL READINESS DATA BASE
                          NARRATIVE WITH RELIABILITY BLOCK
                      AN/SLQ-XX FROM 880411 TO 890331 SW ALL
  CRITICALITY    SHIP STATUS    MODES    FLEET    SHIP CLASS HULL/UIC
   CR,NJ          ALL            B        ALL      ALL

                            RELIABILITY BLOCK
                     U2A1 SIGNAL GENERATOR (2A1)
         USS NEW JERSEY (BB 62)              HULL NUMBER BB    62   SW DIS
         CRITICALITY: NJ   SHIP STATUS:                               FLEET
                     EVENT START: 890228     EVENT END: 890331
 CM:        3.4  LOG:      911.3  OA:       0.0  ADM:      0.0   TOT:      914.7
                     NARRATIVE
AMPLIFIER 2A4 CHASSIS SLIDES 2MP1MP1 AND 2MP1MP2 ARE WARPED
AND DO NOT ALLOW AMPLIFIER TO BE SEATED PROPERLY XXX REPLACE
CHASSIS SLIDES 2MP1MP1  AND 2MP1MP2.

NEXT NARRATIVE(NN) SCROLL NARRATIVE UP(NU) DOWN(ND) SCROL BLOCK UP(BU) DOWN(BD)
                 (PR)INT     (ME)NU     (SO)RT     (HE)LP     (EX)IT
```

REV1291

A3401895

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

TIME METER PRODUCTS

SCREEN INDICATOR	TIME METER PRODUCT
E1	TOTAL ELAPSED METER TIME
E2	ELAPSED METER TIME BY SHIP AND SERIAL NO.

REV1291

A3491.096

TOTAL ELAPSED METER TIME (E1)

TIME METER PRODUCTS

1 – TOTAL ELAPSED METER TIME

```
04/14/89 09:48        OP-03 MATERIAL READINESS DATA BASE
                            TOTAL ELAPSED METER TIME
               NF XXX NOG 1    FROM 870101 TO 871231 SH ALL
  CRITICALITY   SHIP STATUS    MODES   FLEET   SHIP CLASS HULL/UIC
   CR            ALL           A       ALL     ALL
                                                            TOTAL
                         METER NAME                       METER TIME
                              A                            80919.1
                              B                            21062.6
                              C                            93606.7
                              D                           110924.7
                              E                            32971.4
                              F                           113021.0
                              G                            68602.6
                              H                            88912.3
                              I                             9875.7
               ACTIVE TIME                                157368.0
NO MORE DATA

* - NUMBER OF ROUNDS FIRED, ** - NUMBER OF CYCLES
     (PR)INT     (MO)RE     (ME)NU     (PRE)V-DATA     (HE)LP     (EX)IT

*
```

REV1291

A3401.097

NAVAL WARFARE ASSESSMENT CENTER, CORONA

NWAC **PRODUCTS**

ELAPSED METER TIME BY SHIP AND SERIAL NUMBER (E2)

TIME METER PRODUCTS

1 – TOTAL ELAPSED METER TIME

2 – ELAPSED METER TIME BY SHIP AND SERIAL NO

```
06/15/89 15:52        OP-03 MATERIAL READINESS DATA BASE
                  ELAPSED METER TIME BY SHIP AND SERIAL NUMBER
                     MK XX MOD 1 FROM 880101 TO 881231 SN ALL
 CRITICALITY   SHIP STATUS   MODES   FLEET   SHIP CLASS HULL/UIC
  CR,MJ           ALL          A       ALL      ALL
```

HULL		SERIAL NO	METER ID	ELAPSED TIME	METER ID	ELAPSED TIME
CV	2	32	001	2401.7	002	749.8
			003	2166.9	004	2717.7
			005	1519.4	007	3228.3
			008	2548.5	009	2648.4
			01[illegible]	473.3	T	5448.0
CV	66	35	00[illegible]	[illegible]470.4	002	1083.5
			00[illegible]	[illegible]	004	3927.0
			005	2195.5	007	4664.6
			008	3682.4	009	3826.8
			010	683.9	T	7872.0
CVN	69	1	001	2800.8	002	893.0
			003	2597.2	004	3103.3
			005	2016.3	007	358[illegible].5
			008	2976.1	009	2939.7

* - NUMBER OF ROUNDS FIRED, ** - NUMBER OF CYCLES
(LEG)END METER ID (PR)INT (MO)RE (ME)NU (PRE)V-DATA (HE)LP (EX)IT

\>

REV1291 A3401.098

APPENDIX E

SHIPS PROGRAM-GUN SYSTEM DATA COLLECTION SCREENS

5 INCH 54 MK45 NAVAL GUN SYSTEM DATA COLLECTION PROGRAM

S	Shot fired NO gun failure
F	Gun FAILURE proceed to record
O	Record On Station Time
D	Record Ready Time
I	Record Mission Complete Time
C	Record Check Fire Time
K	Record Cancel Check Fire Time
B	Record Counter Battery Time

Current Mount MT 51
Rounds Fired During Mission 6
Rounds Fired Since Data Collection Began 6

Press one of the indicated keys to continue

M – Manual entry P – Previous screen
R – Repair Time Complete Z – Shift Mounts
E – Gunshoot has ended

5 INCH 54 MK45 NAVAL GUN SYSTEM DATA COLLECTION PROGRAM

1 – LOWER ACCUMULATOR SYSTEM
2 – LOWER HOIST ASSEMBLY
3 – LOADER DRUM ASSEMBLY
4 – UPPER HOIST ASSEMBLY
5 – FUSE SETTER ASSEMBLY
6 – UPPER ACCUMULATOR ASSEMBLY
7 – CRADLE AND RAMMER ASSEMBLY
8 – GUN BARREL HOUSING ASSEMBLY
9 – BREECH MECHANISM
10 – RECOIL COUNTERRECOIL SYSTEM
11 – EMPTY CASE TRAY ASSEMBLY

N – Next screen
P – Previous screen – no gun failure
Q – Quit program

5 INCH 54 MK45 NAVAL GUN SYSTEM DATA COLLECTION PROGRAM

R – Gun system has been repaired – continue with mission

Choose Mount that has been Repaired

1 – Mount 51

2 – Mount 52

P – Previous screen – choose a different block
Z – Shift gunmounts Continue with Mission
M – Manual data entry

APPENDIX F

SPOTTERS PROGRAM DATA COLLECTION SCREENS

5 INCH 54 MK45 NAVAL GUN SYSTEM DATA COLLECTION PROGRAM

F = Function

N = NonFunction

L = Lost Round

H = Hit

R = Repeat

ROUNDS FIRED SINCE DATA COLLECTION BEGAN 0

Choose from the one of the indicated keys
M = Manual entry
P = Previous screen
E = Gunshoot has ended

5 INCH 54 MK45 NAVAL GUN SYSTEM DATA COLLECTION PROGRAM

L = Left

R = Right

A = Add

D = Drop

U = Up

D = Down

Choose from the one of the indicated keys

N = Next Shot

P = Previous screen

APPENDIX G

PROJECTILE AND POWDER DATA FROM 44 SHIPS

JULIAN DATE	SHIP NAME	SHIP TYPE	HE	PUFF	STAR	GUN DELAY	POWDER DELAY	HE DUDS	PUFF DUDS	DARK STAR	RIPPED CHUTE	STAR DELAY	RNDS LOST	TOTAL RNDS	FX	OBS
1111	SCOTT	DDG	72	0	9	1	0	0	0	5	0	5	0	81	P	O
1128	VALDEZ	FF	116	0	3	4	0	0	0	0	0	0	0	119	P	B
1220	NICHOLSON	DD	54	0	0	4	3	0	0	0	0	0	2	54	P	B
1259	LEYTE GULF	CG	84	0	16	1	0	1	0	5	4	9	1	100	P	O
1277	GETTYSBURG	CG	88	0	7	0	2	0	0	0	[illegible]	1	0	95	O	B
1297	BRISCOE	DD	80	0	5	1	0	7	0	0	2	2	1	85	O	B
1299	STUMP	DD	100	0	6	1	0	2	0	0	0	0	0	106	O	B
1300	NICHOLSON	DD	128	0	31	10	2	1	0	6	0	6	0	159	S	B
1302	TRIPPE	FF	46	0	4	1	0	0	0	0	0	0	0	50	P	O
1330	HUE CITY	CG	74	0	8	0	0	0	0	1	1	2	0	82	O	O
1341	WAINWRIGHT	CG	94	0	3	4	0	4	0	2	0	2	4	97	P	O
2017	AINSWORTH	FF	183	0	25	2	0	1	0	0	2	2	1	208	S/O	B
2017	PHILLIPINE SEA	CG	101	0	3	0	0	7	0	0	0	0	3	104	O	O
2019	COMPTE DE GRASSE	DD	31	0	8	0	0	1	0	0	0	0	1	39	S	O
2019	GATES	CG	18	0	0	0	0	1	0	0	0	0	0	18	P	O
2041	MACDONOUGH	DDG	118	0	4	0	0	1	0	0	0	0	8	122	P	O
2043	BOWEN	FF	115	0	45	1	0	8	0	3	1	4	0	160	S	O
2045	HART	FF	123	0	25	8	0	0	0	1	2	3	0	148	S/O	B
2052	BROWN	FF	71	0	8	0	0	0	0	0	0	0	8	79	O	B
2076	SPRUANCE	DD	147	0	3	2	0	0	0	0	0	0	0	150	S/O	O
2066	TRUETT	FF	0	191	32	4	0	0	2	3	4	7	1	223	S/O	B
2100	MONESTER	FF	0	202	29	8	0	0	0	1	9	10	6	231	S	B
2100	OBANNON	DD	0	77	6	2	0	0	0	2	0	2	0	83	O	B
2112	MCCANDLESS	FF	0	121	23	6	0	0	0	0	1	1	0	144	O	B
2122	YORKTOWN	CG	264	0	5	1	0	10	0	0	0	0	35	269	S/O	O
2127	MOOSEBRUGGER	DD	71	0	10	0	1	0	0	1	1	2	0	81	O	B
2127	PETERSEN	DD	0	76	5	5	0	0	3	0	0	0	0	81	O	B
2177	ANZIO	CG	92	0	3	0	0	4	0	0	[illegible]	1	4	95	O	O
2185	NASSAU	LHA	0	72	6	1	0	0	4	0	0	0	0	78	O	O
2197	RODGERS	DD	0	79	16	3	0	0	0	0	0	0	0	95	O	A
2204	DEYO	DD	0	86	7	2	0	0	2	0	0	0	0	93	O	B
2211	HAYLER	DD	0	66	6	1	0	0	0	0	2	2	0	72	O	B
2213	CARRON	DD	0	84	12	1	0	0	4	0	0	0	0	96	O	O
2214	CAPODANNO	F	0	38	5	0	0	0	1	0	0	0	1	43	ABR	O
2220	MONTGOMERY	FF	0	0	0	0	0	0	0	0	0	0	0	0	ABR	B
2334	HUE CITY	CG	0	237	38	0	0	0	7	2	3	5	11	275	S	O
2259	LEYTE GULF	CG	0	75	9	0	0	0	5	0	1	1	5	84	ABR	O
2265	MISSISSIPPI	CGN	0	256	7	5	0	0	3	3	0	3	3	263	O	B
2270	NICHOLSON	DD	0	148	50	4	1	0	0	3	2	5	0	198	S	B
2309	KIDD	DDG	0	97	5	2	0	0	6	0	2	2	4	102	O	O
2334	ARLEIGH BURK	DDG	0	109	3	0	0	0	8	0	0	0	6	112	O	O
2337	JOSEPHUS DANIELS	CG	0	70	8	0	0	0	1	2	1	3	1	78	O	O
2342	HEWES	FF	0	86	14	2	0	0	0	0	0	0	3	100	O	B
2343	VIRGINIA	CGN	0	71	4	1	0	0	2	0	0	0	3	75	O	B
	TOTALS	44	2270	2241	516	88	9	48	48	40	40	80	112	5027		
								POWDER FAIL %	HE FAIL %	PUFF FAIL %			STAR FAIL %			
								0.00179	0.00115	0.02053			0.15504			

APPENDIX H

DATA COLLECTED AND USED IN THE ANALYSIS

DATE	SHIPS NAME	ROUNDS FIRED
4/24/91	USS SCOTT	81
10/1/91	USS GETTYSBURG	95
10/24/91	USS BRISCOE	85
10/26/91	USS STUMP	106
11/26/91	USS HUE CITY	82
4/10/92	USS O'BANNON	83
5/7/92	USS MOOSBRUGGER	81
6/26/92	USS PETERSEN	81
7/16/92	USS ROGERS	95
7/23/92	USS DEYO	93
7/30/92	USS HAYLER	72
12/9/92	USS VIRGINIA	75
4/13/93	USS SAN JACINTO	87
4/17/93	USS ROGERS	103
		1219 ROUNDS FIRED

BLOCK NUMBER	BLOCK NAME	REPAIR TIME (SECS)	MTTR (SECS)	PERCENT FAILURES
#2	LOWER HOIST	20	20	.00082%
#5	FUSE SETTER	850		
		1060		
		940		
		840		
		870		
		900		
		970		
		930	920	.00656%
#7	CRADLE and RAM	860		
		800		
		700		
		810		
		995	833	.00410%
#9	BREECH	14929	14929	.00082%
#10	TRAIN POWER DRIVE	2632	2632	.00082%
#37	28V POWER SUPPLY	687	687	.00082%
#41	BLOWER MOTOR	763		
		699	720	.00164%
#43	EP2 PANEL/CABLING	248		
		192	220	.00164%
				.01722%

Gun Failure Rate = 21 Failures / 1219 Rounds Fired = .01722%

APPENDIX I

SIMULATION DATA SHEETS

```
***************************************************************************
Output from NGFS at Mon May 31 22:28:37 1993
***************************************************************************
*****************************************
 Rep number:      1
        1.13  Firing Rate For OD____-01GUN-1
        0.22  Firing Rate For OD____-01GUN-2

        0.70  AveFiringRate
        6.83  MissionTime
      149.19  IntegralTargetValue
        1.00  Empirical Ef
        3.74  Theoretical Ef
*****************************************
 Rep number:      2
        1.93  Firing Rate For OD____-01GUN-1
        1.02  Firing Rate For OD____-01GUN-2

        1.47  AveFiringRate
        8.77  MissionTime
      157.91  IntegralTargetValue
        2.77  Empirical Ef
        3.74  Theoretical Ef
*****************************************
 Rep number:      3
        1.18  Firing Rate For OD____-01GUN-1
        0.22  Firing Rate For OD____-01GUN-2

        0.70  AveFiringRate
        6.83  MissionTime
      149.19  IntegralTargetValue
        1.00  Empirical Ef
        3.74  Theoretical Ef
*****************************************
 Rep number:      4
        1.18  Firing Rate For OD____-01GUN-1
        0.22  Firing Rate For OD____-01GUN-2

        0.70  AveFiringRate
        6.83  MissionTime
      149.19  IntegralTargetValue
        1.00  Empirical Ef
        3.74  Theoretical Ef
*****************************************
 Rep number:      5
        1.18  Firing Rate For OD____-01GUN-1
        0.22  Firing Rate For OD____-01GUN-2

        0.70  AveFiringRate
        6.83  MissionTime
      149.19  IntegralTargetValue
        1.00  Empirical Ef
        3.74  Theoretical Ef
***************************************************************************
***************************************************************************
End of Simulation Stats
         5                  Total number of Repetitions
        1.33 +/-      0.29  Average Firing Rate For OD____-01GUN-1
        0.38 +/-      0.31  Average Firing Rate For OD____-01GUN-2

        0.85 +/-      0.30  Global Average Firing Rate

        7.22 +/-      0.76  Average Mission Time
      158.94 +/-     19.10  Average Time Integral Target Value
***************************************************************************
***************************************************************************
NGFS Completed execution successfully at Mon May 31 22:28:38 1993
***************************************************************************
***************************************************************************
```

Results From NGFS Mission Z-40-G. (Callahan, 1993)

```
******************************************************************
Output from NOFS at Mon May 31 11:49:54 1993
******************************************************************
*****************************************
 Rep number:      1
       1.07   Firing Rate for OD____=01DUN=1
       0.38   Firing Rate for OD____=01DUN=2

       0.67   AveFiringRate
       8.10   MissionTime
     167.63   IntegralTargetValue
       1.00   Empirical Ef
       1.03   Theoretical Ef
*****************************************
 Rep number:      2
       1.43   Firing Rate for OD____=01DUN=1
       0.65   Firing Rate for OD____=01DUN=2

       1.04   AveFiringRate
      11.10   MissionTime
     279.48   IntegralTargetValue
       1.01   Empirical Ef
       1.03   Theoretical Ef
*****************************************
 Rep number:      3
       1.07   Firing Rate for OD____=01DUN=1
       0.38   Firing Rate for OD____=01DUN=2

       0.67   AveFiringRate
       8.10   MissionTime
     167.63   IntegralTargetValue
       1.00   Empirical Ef
       1.03   Theoretical Ef
*****************************************
 Rep number:      4
       0.70   Firing Rate for OD____=01DUN=1
       0.28   Firing Rate for OD____=01DUN=2

       0.49   AveFiringRate
      10.90   MissionTime
     105.57   IntegralTargetValue
       1.00   Empirical Ef
       1.03   Theoretical Ef
*****************************************
 Rep number:      5
       1.07   Firing Rate for OD____=01DUN=1
       0.38   Firing Rate for OD____=01DUN=2

       0.67   AveFiringRate
       8.10   MissionTime
     167.63   IntegralTargetValue
       1.00   Empirical Ef
       1.03   Theoretical Ef
******************************************************************
******************************************************************
End of Simulation State
       5                   Total number of Repetitions
       1.07 +/-     0.33   Average Firing Rate for OD____=01DUN=1
       0.39 +/-     0.14   Average Firing Rate for OD____=01DUN=2

       0.73 +/-     0.18   Global Average Firing Rate

      10.00 +/-     1.38   Average Mission Time
     199.57 +/-     61.63  Average Time Integral Target Value
******************************************************************
******************************************************************
NOFS Completed execution successfully at Mon May 31 11:49:57 1993
******************************************************************
******************************************************************
```

Results From NOFS Mission Z-42-0, (Callahan, 1993)

```
*************************************************************************
Output from NGFS at Mon May 31 22:35:41 1993
*************************************************************************
****************************************
 Rep number:      1
        1.36   Firing Rate For DD____-01GUN-1
        0.23   Firing Rate For DD____-01GUN-2

        0.80   AveFiringRate
        5.30   MissionTime
       91.22   IntegralTargetValue
        1.00   Empirical Ef
        3.84   Theoretical Ef
****************************************
 Rep number:      2
        2.00   Firing Rate For DD____-01GUN-1
        1.03   Firing Rate For DD____-01GUN-2

        1.51   AveFiringRate
        7.70   MissionTime
      131.16   IntegralTargetValue
        2.49   Empirical Ef
        3.84   Theoretical Ef
****************************************
 Rep number:      3
        1.36   Firing Rate For DD____-01GUN-1
        0.23   Firing Rate For DD____-01GUN-2

        0.80   AveFiringRate
        5.30   MissionTime
       91.22   IntegralTargetValue
        1.00   Empirical Ef
        3.84   Theoretical Ef
****************************************
 Rep number:      4
        1.36   Firing Rate For DD____-01GUN-1
        0.23   Firing Rate For DD____-01GUN-2

        0.80   AveFiringRate
        5.30   MissionTime
       91.22   IntegralTargetValue
        1.00   Empirical Ef
        3.84   Theoretical Ef
****************************************
 Rep number:      5
        1.36   Firing Rate For DD____-01GUN-1
        0.23   Firing Rate For DD____-01GUN-2

        0.80   AveFiringRate
        5.30   MissionTime
       91.22   IntegralTargetValue
        1.00   Empirical Ef
        3.84   Theoretical Ef
*************************************************************************
*************************************************************************
End of Simulation Stats
          5                   Total number of Repetitions
       1.49 +/-       0.28   Average Firing Rate For DD____-01GUN-1
       0.39 +/-       0.31   Average Firing Rate For DD____-01GUN-2

       0.94 +/-       0.28   Global Average Firing Rate

       5.78 +/-       0.94   Average Mission Time
      99.21 +/-      15.46   Average Time Integral Target Value
*************************************************************************
*************************************************************************
NGFS Completed execution successfully at Mon May 31 22:35:42 1993
*************************************************************************
*************************************************************************
```

Results From NGFS Mission Z-43-G. (Callahan, 1993)

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